THE MANUFACTURE OF THE LEWIS MACHINE GUN

By Frank A. Stanley

This foreword is presented to give a general idea of the character of the Lewis gun, and of the workmanship involved in manufacturing it upon a strictly interchangeable basis. All parts are subjected to one hundred per cent. inspection, and each and every piece manufactured will interchange absolutely so that guns will assemble any time, anywhere, from parts of any date made under this most complete system. The gun may be assembled or stripped without special tools of any kind, and in the briefest period of time. A further proof of the high character of workmanship and material is found in the fact that a gun has fired over 300,000 rounds and still functions perfectly. Certain parts, such as the barrel, were changed on account of the necessary wear.

IT RECENTLY has been my privilege to spend some little time at the plant of the Savage Arms Corporation at Utica, New York, where every opportunity was afforded me for examining manufacture, inspection, assembling and testing of the Lewis machine gun.

FIGS. 2 AND 3. THE AMERICAN MODEL LEWIS GUN

The production of this gun forms one of the most interesting systems of manufacture ever employed in a machine plant. It is a clean-cut manufacturing proposition from the start to finish with no hidden processes and no secret operations. The gun is absolutely interchangeable in every respect. This is saying a great deal, but it is strictly true in every sense of the word. In the first place a schedule of limits has been carefully worked out for every member of the gun. There is in these tolerances no overlapping of the dimensions of two parts that are to fit together and the parts as produced to the limit gages, therefore, assembled properly. The tool equipment is of itself of such character, and the order of operations is such, that each operation checks the accuracy of preceding processes, and there is 100 per cent. inspection of the product.

The machine operatives gage the parts as produced by the tools, and while these parts are still on the bench every one of them is gaged by an inspector before it leaves the department. Following this shop inspection all parts are later gaged in the general inspection room. After the harding, bluing and browning processes the parts are reinspected, and after the guns have been assembled a considerable number of shots fired from each in the gallery to test the functioning of the mechanism with the gun placed at all angles and bottom side up. After

this the guns are pulled down and the parts again gone over by another group of inspectors. They are then reassembled ready for the final official inspection. This involves the taking apart of each gun for examination, the mixing of the parts from a group of guns and the assembling again from parts taken promiscuously from these groups so that each completed gun is composed of members taken from ten or more different guns as originally brought into the department.

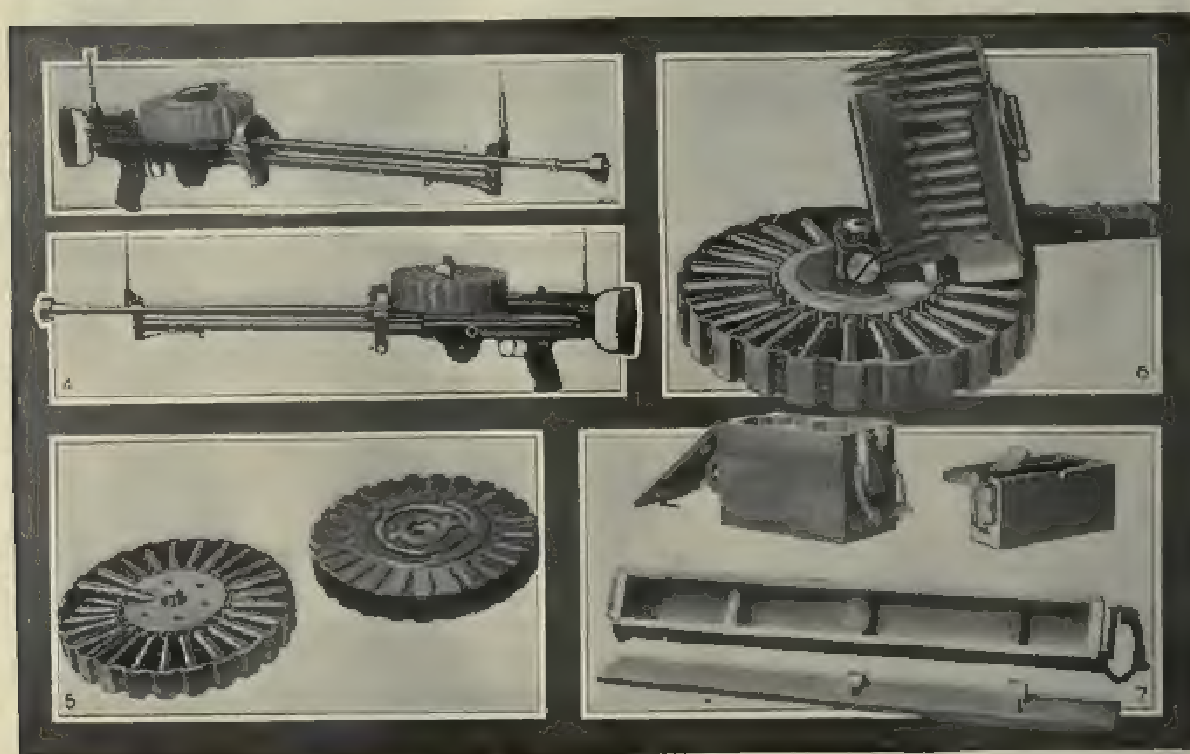
The above brief outline of the course of procedure followed does little more than emphasize the salient features of a shop system that has been so highly developed and thoroughly applied to the attainment of the desired end, a truly interchangeable firearm. In articles to follow, various features of manufacture and inspection will be elaborated upon to show what has been found essential to the successful carrying on of this line of manufacture.

The Lewis gun has already been described in these columns, and no detailed account of its features of design and operation is here required. It may be well, however, to call attention to certain points in the make-up of the gun in this preliminary article in order to show clearly the problems involved in the manufacturing process.

Some interesting general views of the American standard gun are presented in Figs. 1, 2 and 3, while Fig. 4 illustrates the new airplane gun with functioning parts exactly the same as those of the standard model. The radiator is not required on the airplane model, and the magazine is deeper and holds 97 cartridges where 47 only are carried in the standard magazine. In the guns proper there are no differences; in fact, the parts of one gun will interchange with those of the other.

Two magazine illustrations are reproduced in Figs. 5 and 6, and Fig. 7 shows the gun box and the containers for carrying the magazines. In passing it may be stated that the manufacture of the magazines is a press process of high order, which will be discussed later. The steel shell with its corrugations is drawn up in an ingeniously designed die, the rivet holes for the ribs are punched with a radially operated set of tools, and the magazine center of aluminum is milled around the periphery to form a spiral groove, or feed channel for the cartridges, by means of multiple spindle machines carrying a series of formed end mills.

The cartridges, which are the same as used in the Springfield rifle, are loaded into the magazine in the manner shown in Fig. 6, where the magazine is seen upside down with the loading tool attached. A clip full of cartridges is placed in the top of the chute with the bullets toward the center, and as the cartridges are pressed down to strip them from the clip, the magazine is rotated to the right so that the bullets are engaged by the spiral groove or thread in the magazine center and the cartridges thus fed down into the magazine.



FIGS. 4 TO 7 A NUMBER OF PARTS OF THE GUN
Fig. 4—The airplane model. Fig. 5—The magazine. Fig. 6—The magazine loader. Fig. 7—The gun box and magazine containers

The parts of the gun are shown in detail in Figs. 8, 9, 10 and 11, the first of these illustrations representing the barrel and piston group, while Fig. 9 shows the receiver group and trigger mechanism, Fig. 10 the feed mechanism and bolt parts, and Fig. 11 the buttstock loading handle, spade grip and bipod mount. The gun proper contains all told, some 60 parts, and one of the striking features is that only 1 screw and 4 pins are used in its make-up. This means that the taking down

of the gun and its reassembling require nothing in the way of tool equipment except a small spanner for the barrel mouthpiece and a drift for the pins. Aside from the specific uses mentioned for these two tools all operations in stripping the gun and putting it together are accomplished with the aid of a cartridge, the point of the bullet being introduced in the various channels and holes where parts lock together. So readily are the stripping and assembling operations performed that a man blindfolded can take the gun apart and reassemble it without difficulty.

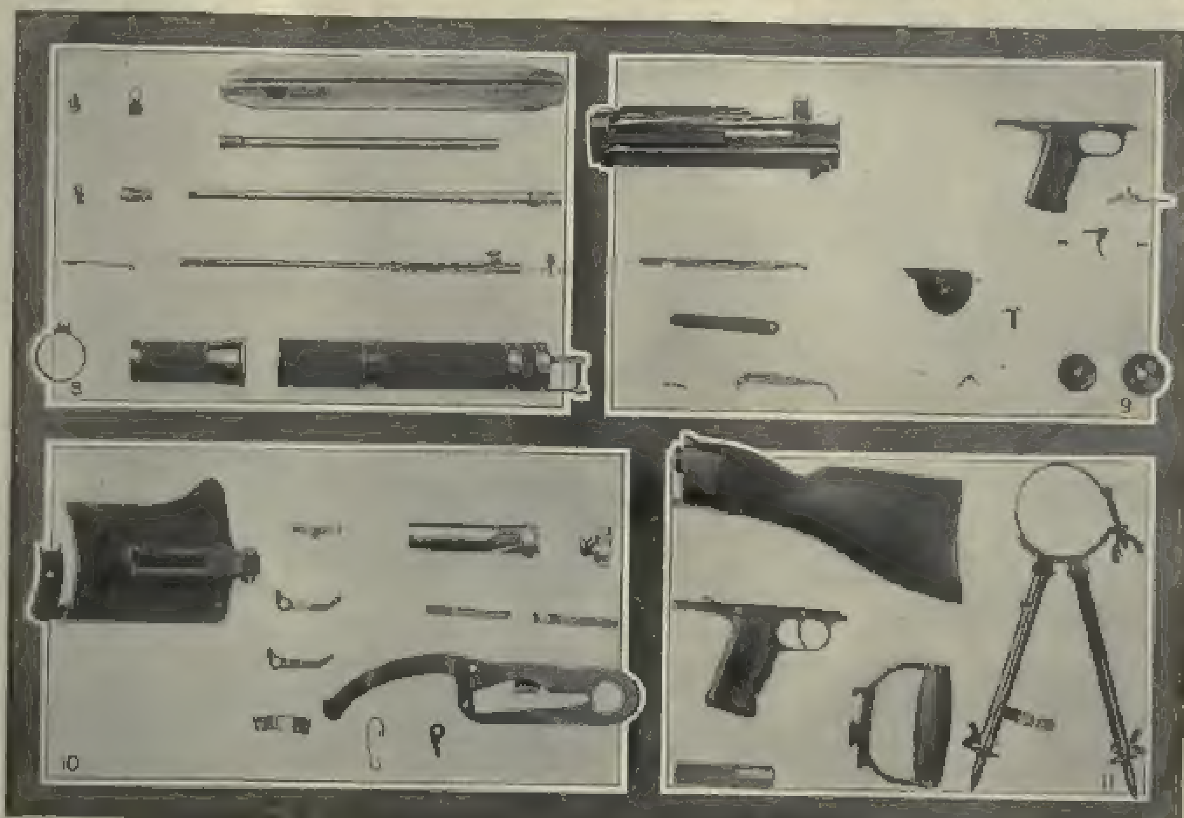
Of all the parts entering into the gun construction, the most interesting one from a mechanical point of view is the receiver seen in the upper left-hand corner of Fig. 9. This is manufactured from a vanadium steel drop-forging weighing in the rough 18 lb. and cut down on the machining operations to a finish weight of 3½ lb. only. It will not be attempted in this article to describe in detail the series of operations on this intricate piece of work, these will be dealt with, however, in articles that are to follow.

Some idea of the extent and nature of the different shop processes followed in the manufacture of the receiver may be gathered from the following data: In carrying the vanadium steel drop-forging through from the rough to the finished receiver there are over 150 distinct operations. Of these 26 are performed on power milling machines, 18 on hand milling machines, and 38 on profilers, so that practically one-half of the total number of operations are accomplished with milling and profiling cutters of one kind or another. Some half dozen or more operations are handled on turret lathes and about the same number on shaping machines. It is interesting to note that the drilling machine is used in only about 6 operations on this particular piece. Reaming, grinding, and lapping processes are included to the extent of a dozen or more in the series of machine operations, and all of this work, whether on a milling, profiling, drilling or some other machine, is accomplished with the aid of most carefully designed fixtures and complete sets of gaging apparatus.

It will be understood, of course, that while the mechanical means for completing all the gun parts have been developed to a remarkable extent to eliminate hand operations so far as possible, there must necessarily be a few surfaces where hand work at the bench is required in bringing certain points accurately to gage, and where these hand operations are applied as in finish filing occasional cuts, the same important class of gaging and testing apparatus is employed for assuring interchangeability as is provided for the machine operations.

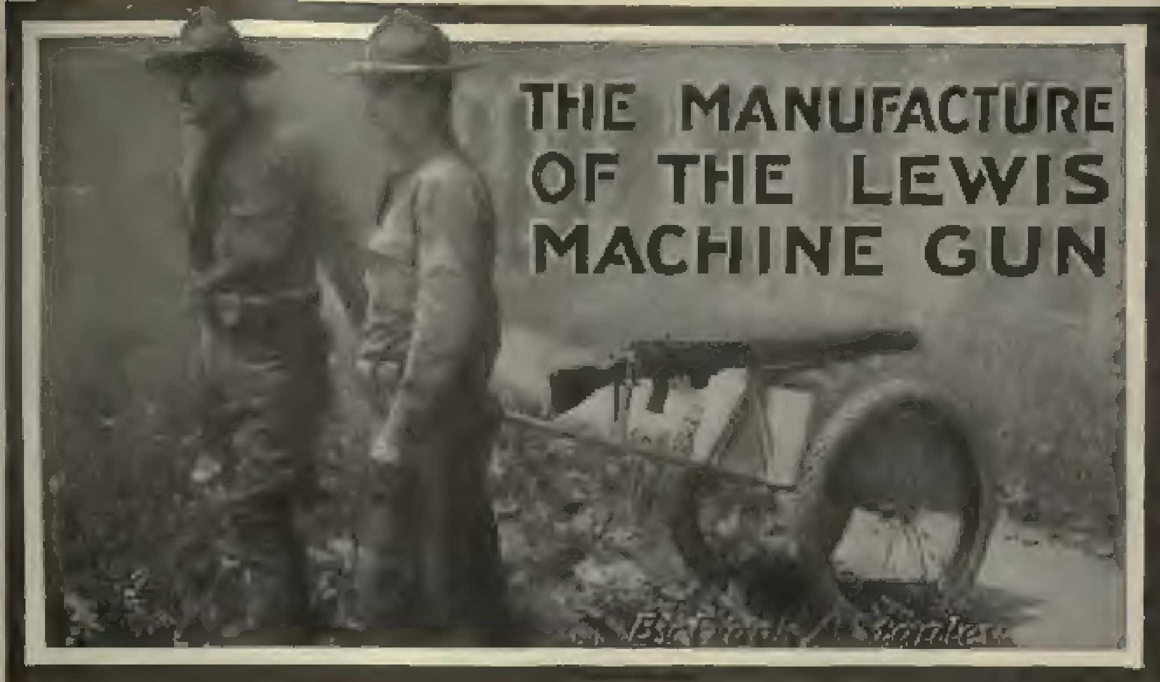
The character of the gages referred to, in connection with both machine and hand processes, is such as to justify a detailed account that will be given in subsequent articles. It is obvious that the system of tolerance, and the gaging system must form the basis of this most remarkable piece of interchangeable gun manufacture.

(To be continued)



FIGS. 8 TO 11. VARIOUS SMALL BUT IMPORTANT PARTS

Fig. 8—The barrel and radiator group. Fig. 9—The receiver and trigger mechanism. Fig. 10—The feed mechanism and bolt. Fig. 11—The butt stock, loading handle, spade, grip and bipod mount



II. The Receiver—I

The operations on the receiver are of great variety, and a high degree of accuracy is essential in all cases. There are over one hundred and fifty actual operations in all. The important locating point is established by the large hole put through the entire length of the forging, and after the completion of this operation the other cuts are positioned in positive relation to this hole. Details are given of receiver limits and tolerances, and of methods of milling, drilling, reaming and lapping.

THE most interesting member of the Lewis machine gun considered from a mechanical point of view is the receiver, and in this first detailed article on the methods of the Savage Arms Corporation, Utica, N. Y., the illustrations will be confined to the receiver itself and will indicate the operations by which it is machined.

The receiver in various stages from drop forging to finished piece is illustrated in Fig. 12. This group shows, of course, only a very few of the numerous stages through which the work progresses in course of manufacture, but it gives a general idea of some of the important machining cuts which are required.

The vanadium-steel drop forging shown in the upper left-hand corner of the group weighs 18 lb.; the finished receiver shown in the lower row at the center and left, weighs only 3½ lb. In other words, in the 150 and more, distinct operations through which the work passes, nearly 15 lb. of metal are cut away to produce the finished piece.

It will be noticed that the drop forging is formed with a thin lug seen projecting at the right. This is for a test piece for each forging and before the work starts in the shop, the test lug goes to the laboratory for the determination of important characteristics.

The receiver is shown in plan and sections in the assembly-gun drawing, Fig. 13; the various views illustrate the manner in which the other members such as barrel, radiator-locking piece, feed cover, butt tang, etc., are attached. The 62 parts all told, of the gun proper, can be put together and taken apart without special tools of any kind, so no tool kit is required in service.

Important Details

Reference has been made in another article to the comprehensive system of limits and tolerances which have been established by the manufacturers to produce all parts of the gun on a positively interchangeable basis, so that any part whatsoever will fit instantly in place in any gun made at any date under this system. It is a liberal education in the art of establishing tolerances for interchangeable work, to examine in detail the parts drawings of this gun and check up the allowances for the various dimensions. In this connection attention is called to the detailed drawing in Fig. 14, where it is safe to say there are two or three hundred dimensions all with plus or minus limits. The other parts of the gun are dimensioned in similar manner and there is no overlapping or interference whatsoever, between maximum or minimum parts, for complete sets of gages are used for every piece, and the gages are so constructed and maintained that work which gages properly, will fit together absolutely.

The drawing shows some of the allowances plus or minus to be very minute; on other dimensions more liberal allowances are permitted. In each instance the character of the fit desired has been thoughtfully considered and limits and tolerances established accordingly.

It is a shop truth that where limits are fixed upon too

fine a basis production will necessarily be hampered; it is equally true that an insufficient degree of refinement in such practice will make impossible truly interchangeable work. It is also the truth that the word "interchangeable" has various grades of meaning in different factories and what would be considered interchangeable workmanship on certain shop products would be anything else but that, if considered in a more highly refined line of manufacture.

The present-day requirements on firearms have established a finer shade of understanding in regard to interchangeable work than has heretofore been known in factory practice, and it is undoubtedly true that the highest standards yet set up in the manufacture of such material, are those established and maintained for the production of the Lewis gun at the Savage plant.

Returning now to the specific example, the receiver: let us consider one or two classes of fits; first, examine the tolerances in the chamber at the front end which receives the barrel. The smaller diameter beyond the thread carries the dimension 1.0005 in., plus or minus 0.0005 in. The enlarged or counter-bored portion *M* is dimensioned 1.1425 in. plus or minus 0.0005 in. The minimum figures for these holes are therefore respectively 1 in. and 1.142 in. The corresponding figures for the barrel end are 1.000-0.001 in. and 1.142-0.001 in. Now if the chamber in the receiver is made to the maximum limit and the barrel also to the maximum figures there will be for each of the two fits an allowance in the hole of 0.0005 in. above the size of the barrel end. On the other hand if the receiver hole is made to its minimum and the barrel to its maximum, the dimensions of the entering and receiving parts would theoretically read alike, but in practice as the fit on the barrel must go into its ring gage which is permitted no wear whatsoever, it must actually be at least 0.001 in., or 0.0002 in. under its theoretical maximum size and it will therefore enter properly into its seat in the receiver even though the latter may be a minimum sized hole.

Taking now another class of fit, the feed cover on the receiver: the latter has a series of lugs at *NN*, under which are square guide surfaces for holding the feed cover in position. The thickness of the receiver lugs is given as 0.137-0.001 in. and the corresponding cut milled under the feed cover is dimensioned 0.138-0.001 in. The maximum allowance in this fit is then 0.002 in. and the minimum 0.001 in.

There are various cases where an allowance of several thousandths is permissible between entering and receiving surfaces, but here also both are dimensioned with plus and minus limits, and these surfaces are checked with limit gages just the same as in the case of surfaces where finer limits are required.

Another interesting class of fits for sliding parts is represented by the bolt in the receiver where the long hole passing clear through the receiver is lapped practically from end to end to a limit gage measuring 0.905 in. on the small or go end and 0.906 in. on the large or not go end while the bolt itself is ground to 0.902 in. plus or minus 0.001 in. An analysis of the general system of limits and tolerances will be given at greater length in another article in which the data already presented will be included, in order to show something of the character of the results produced by the methods shown in the illustrations that follow.

When the drop-forged receiver comes to the shop the first machine operations as indicated by the accompanying schedule, are the grinding of the forging, the rough

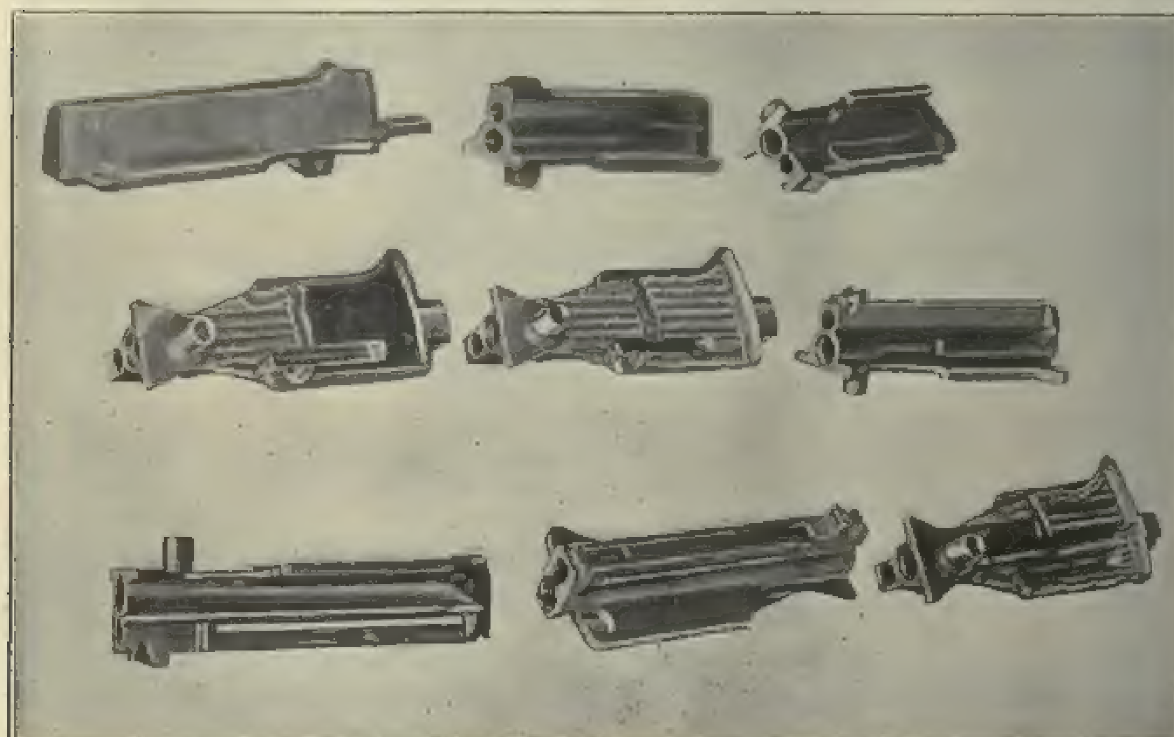


FIG. 12. THE RECEIVER FROM DROP FORGING TO COMPLETED PIECE

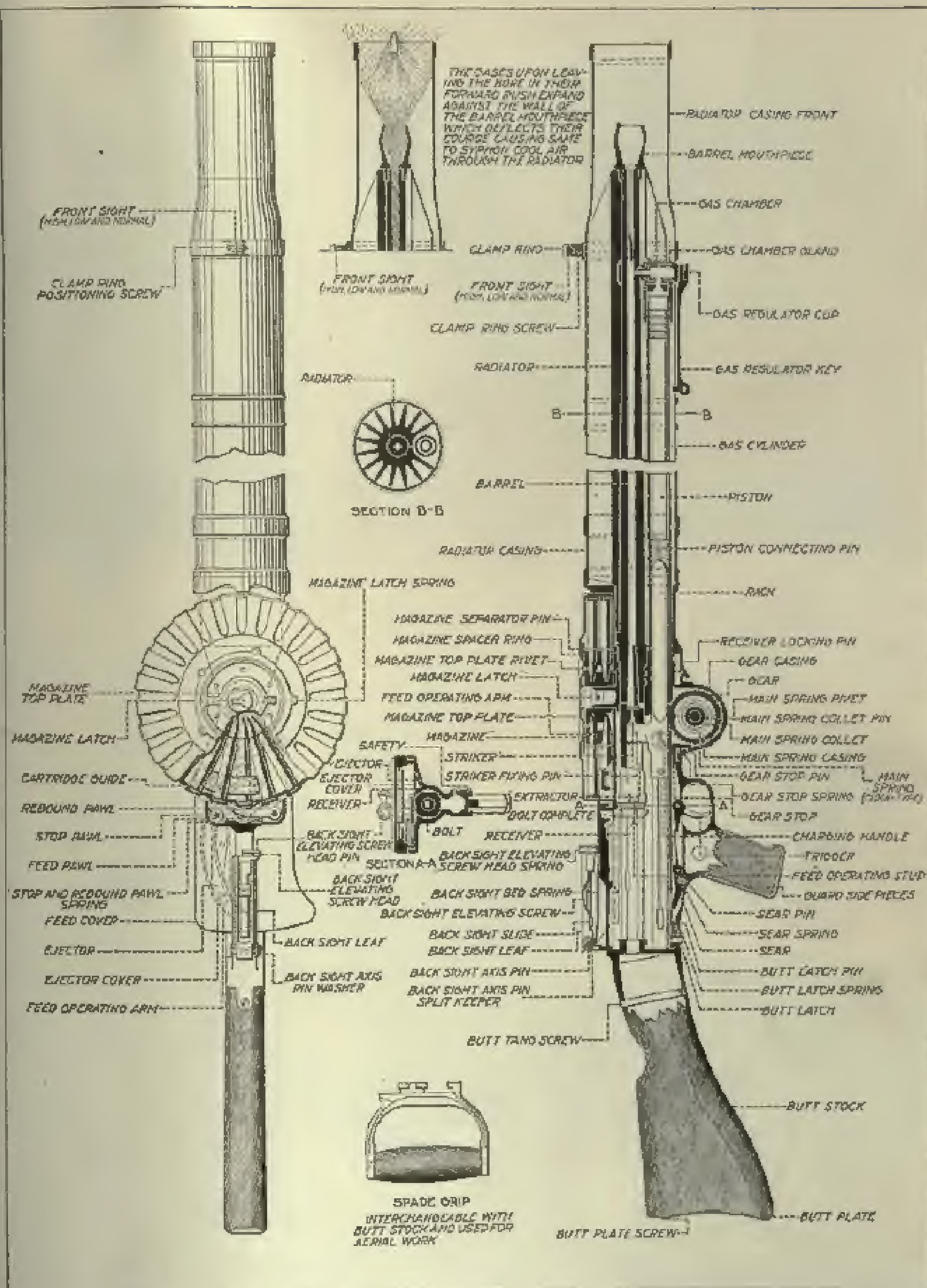


FIG. 13. THE LEWIS GUN, SHOWING RECEIVER AND OTHER PARTS

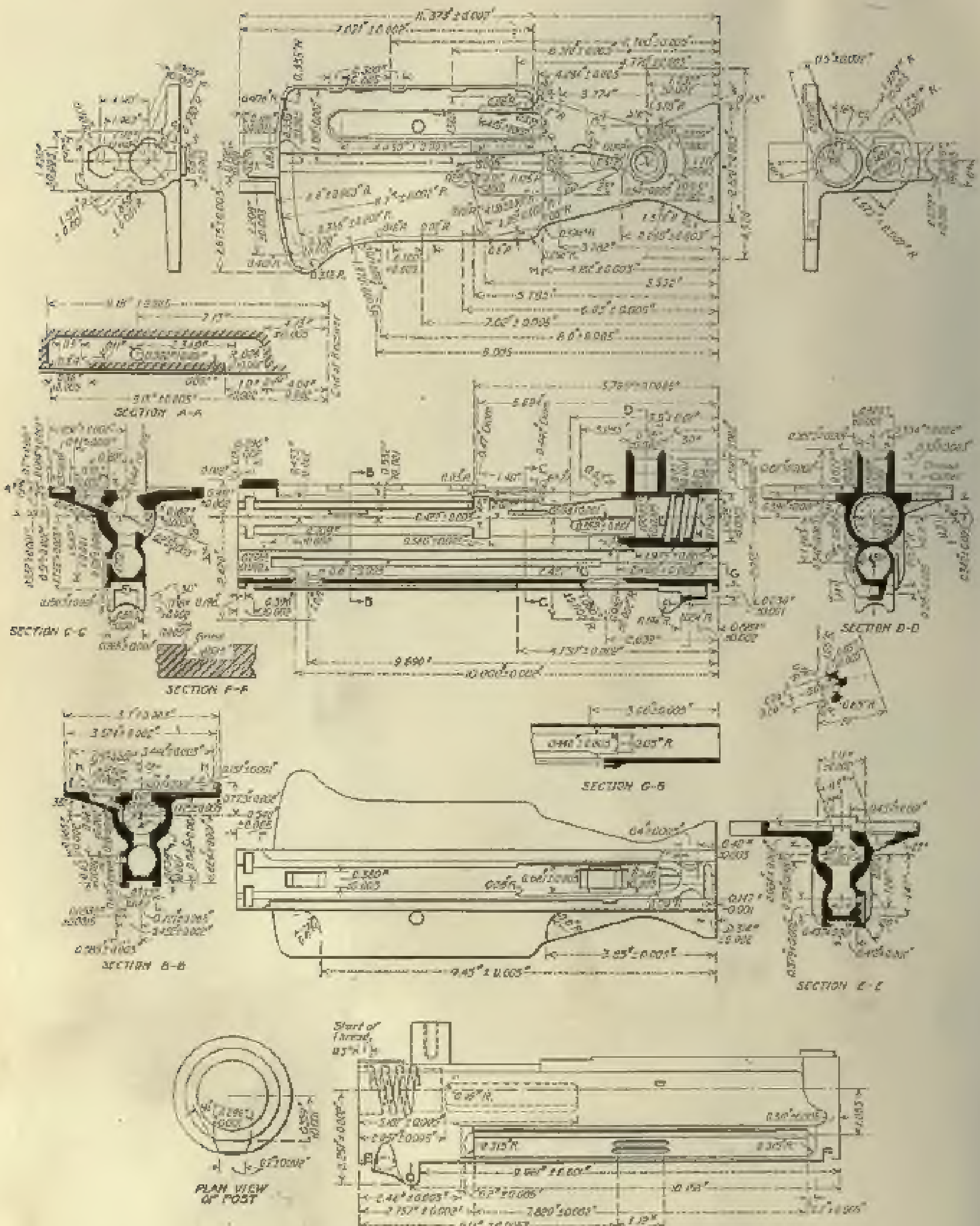


FIG. 14. RECEIVER DETAILS WITH LIMITS AND TOLERANCES

milling of the bottom, and the roughing for Operation 1, which is the straddle milling of the ends to rough dimensions, followed by the rough milling of the sides from end to end with the work held in simple fixtures as shown in Fig. 15; here, in one machine the forging is seen undergoing the milling of the right-hand side while the opposite side of another forging is milled in another machine; the two milling machines in view form part of a large battery of similar machines employed on the receiver work.

The drawing, Fig. 16, represents a double fixture designed for milling of two receivers in which two forg-

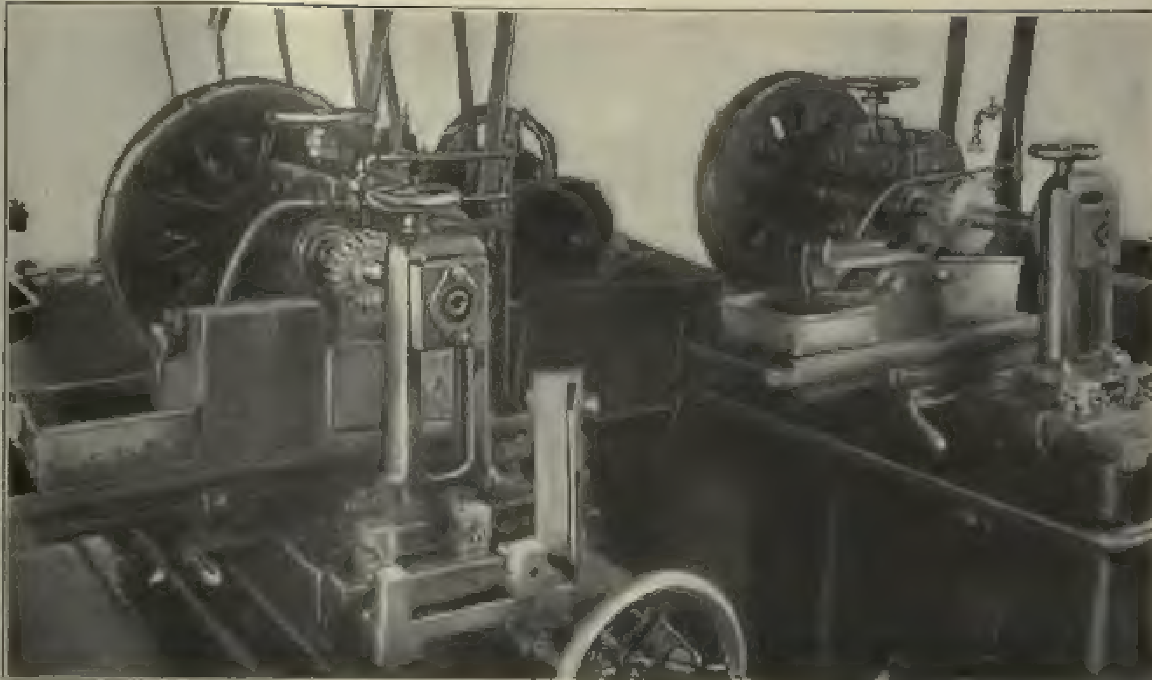


FIG. 15. MILLING THE SIDES OF THE RECEIVER

ings are held simultaneously by means of straps, and through bolts tightened by a pair of nuts at one side of fixture. The details in this drawing show the end stop pin for locating the forgings, the serrated faced shoes upon which the work rests and the rocker-ended clamps by which the forgings are secured in place against the central wall of the fixture.

Figs. 17 and 18 are details of the cutter arbors and formed cutters used in performing this same operation.

The first boring operation on the receiver consists in putting through the large or main hole, which is bored from end to end. This is the hole which in the finished receiver carries the bolt, and which is enlarged and threaded at the front end for the screwing in of the barrel. This hole constitutes the working point by which is located the smaller, parallel hole below for the piston rack which actuates the gun, and is also used for locating the receiver for all subsequent operations

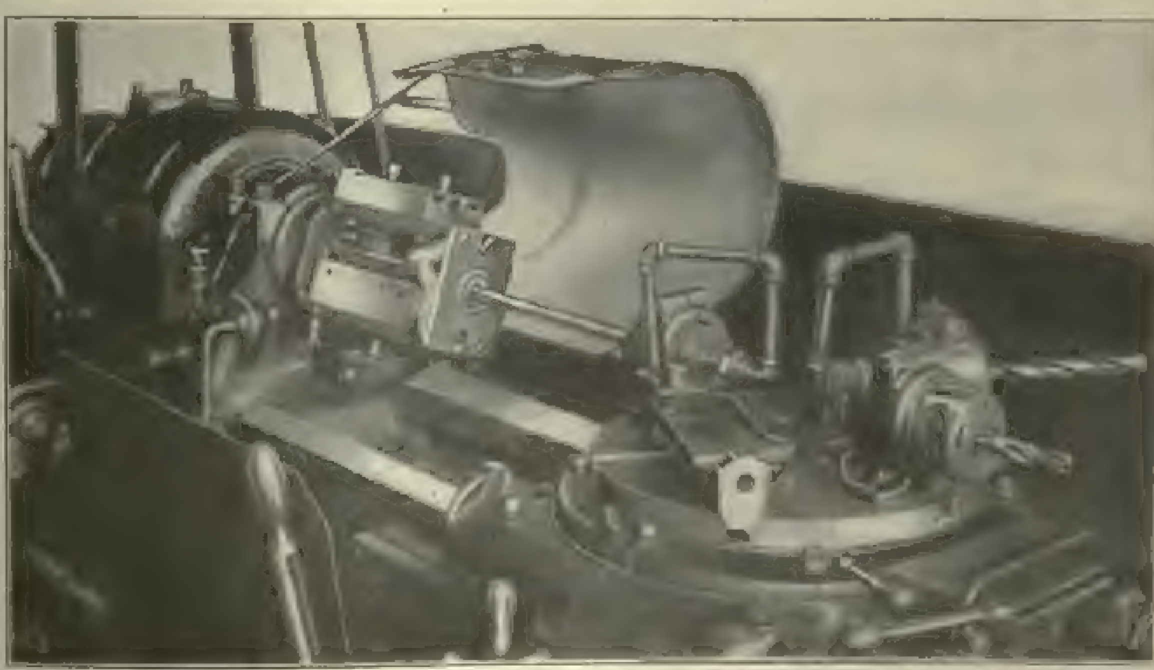
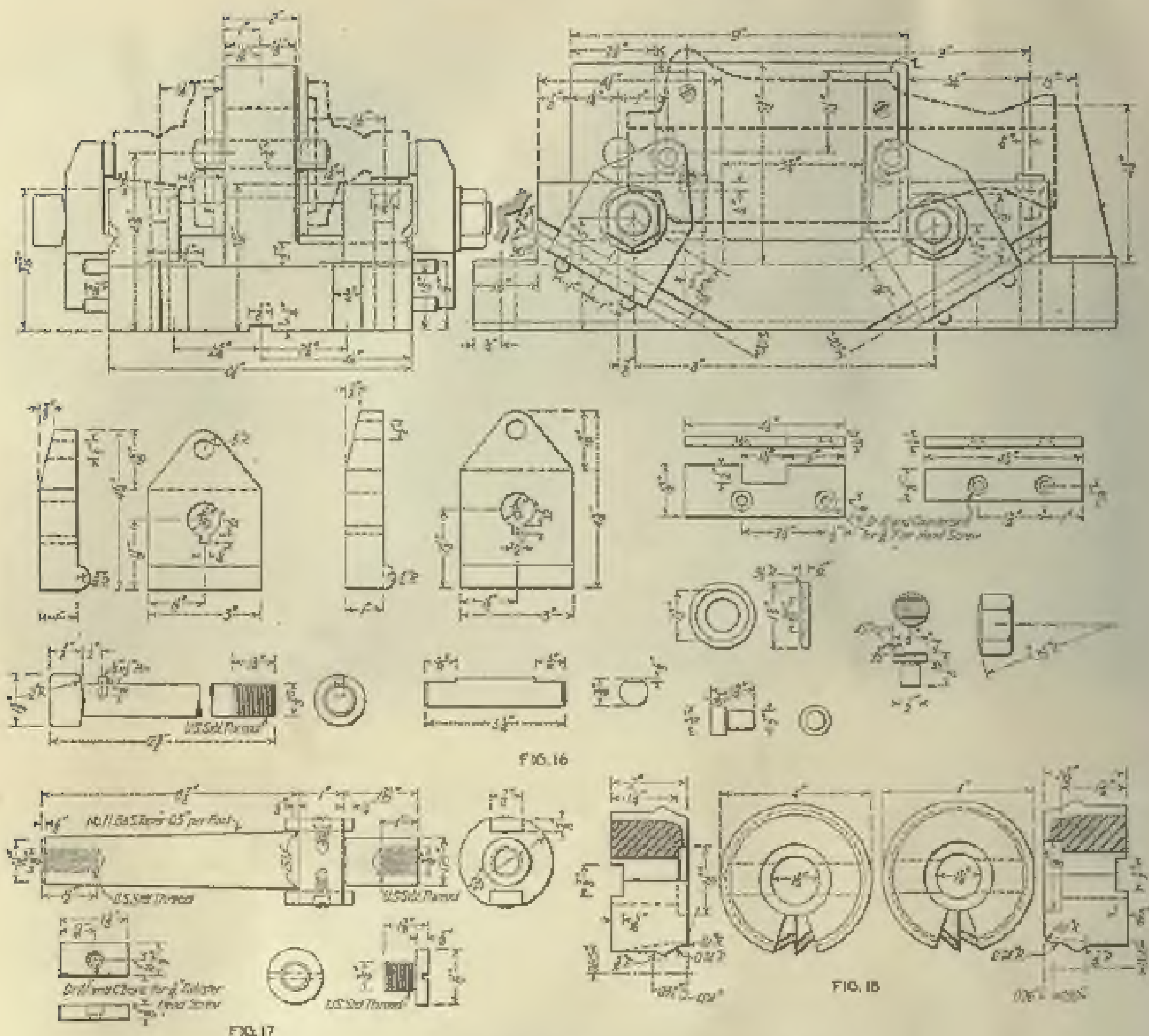


FIG. 19 DRILLING AND REAMING THE MAIN HOLE THROUGH THE RECEIVER



FIGS. 16 TO 18. MILLING FIXTURE AND CUTTER DETAILS

The operation of drilling and reaming this large hole is performed in the turret lathe and is shown in Fig. 19.

The tools used here are a spot drill, through drill and machine reamer; this reamer does not however size the hole to finished dimensions; there are later, at least three machine- and hand-reaming operations.

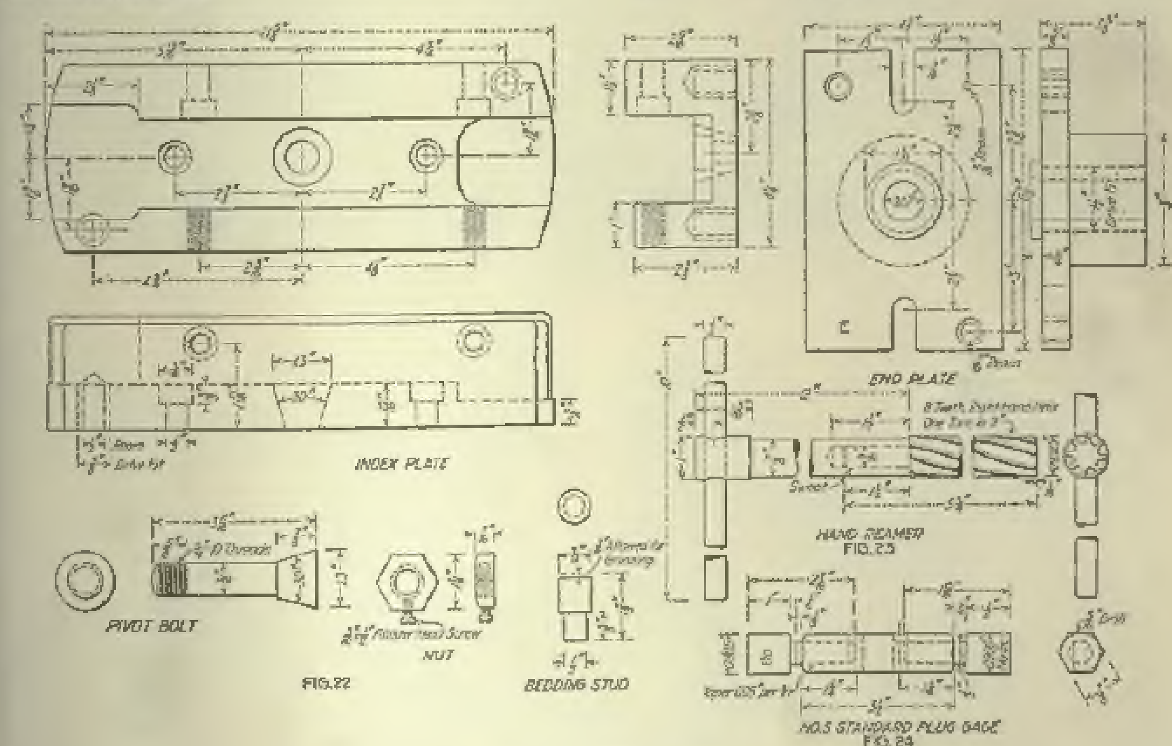
SEQUENCE OF OPERATIONS ON THE RECEIVER

Number	Operation
¼	Grind forging.
½	Rough mill bottom.
¾	Rough for operation 1.
1	Straddle mill ends.
2	Length mill left side (rough).
3	Length mill right side (rough).
4	Drill and ream large hole.
4½	Rough ream large hole in barrel reaming machine.
5	Finish ream large hole in barrel reaming machine.
6	Lap.
7	Drill and ream small hole.
7½	Rough ream small hole.
8	Finish ream small hole.
8½	Lap small hole.
9	Finish face ends to standard length.
10	Finish machine recess locking grooves and counterbore.
10½	Hand ream and counterbore.
11	Mill extractor spring case lug to shape and finish portion of bottom of receiver.
12	Length mill top of platform.
13	Rough mill over grip-slide cut.
14	Rough broach.
15	Finish broach.
16	Length mill grip-slide, finish shape of sides and rough out stock for grip-slide grooves.
17	Finish roundout shape on bottom of receiver.
17½	Rough straddle mill underside of table at left and right sides.
18	Finish straddle mill underside of table at left and right sides.
19	Length mill circle at front end and groove on left side.
20	....
21	Length mill outside shape of bolt boss on left side.
22	Length mill outside shape of bolt boss on right side.
23	Mill left side of spring case lug.
24	Mill right side of spring case lug and safety clearance slot.
25	Length mill safety clearance slot on left side.
26	....
27	Length mill ejector clearance slot.
28	Length mill ejector opening.
29	Profile full outside shape (rough).
29½	Profile full outside shape (finish).
30	Undercut grip-slide groove.
31	Profile platform surface at front end and finish locking lug top.
32	Profile platform rear end.
33	Profile underside of platform on left side.
33½	Finish gear casing stop shoulder.
34	Profile continuation of grip-slide cut.
35	Profile feed-arm clearance.
36	Profile ejector clearance slot.
37	Drill small hole.
38	Drill and ream all holes except hinge-pin hole.
39	Drill and ream magazine boss.
40	Hub magazine boss.
41	Drill and ream hinge-pin hole.
42	Finish rear end of bolt-lug slot on top of receiver.
43	Rough out cartridge clearance slot.
44	Straddle mill front end of safety lug.
45	....
46	Square up ends of safety clearance cut on left side.
47	....
48	Length mill safety-locking notches on left side.
49	Mill gear clearance slot.
50	Mill gear clearance slot.
51	....
52	Profile front end of firing pin clearance slot.
52¼	Shave front end of firing-pin clearance slot.
52½	Mill angle at front end of firing pin lug slot.
53	Shave bolt locking lug clearance slot (wide).
54	Shave bolt locking lug clearance slot (narrow).
55	Shave bolt cam lug clearance slot.

Number	Operation
56	Length mill charging handle clearance slots.
57	Finish bolt bore cuts at rear end.
58	Finish front and rear ends of safety clearance cuts on left side.
59	....
60	Profile magazine clearance at front of feed cover locating surface, locking slot at front of magazine boss and finish feed cover locating lug.
61	Profile small radii and feed arm clearance and finish.
62	Profile and finish small radius at front end of receiver.
63	Profile feed cover locating lug at rear end.
64	Profile feed cover locking cut.
65	Profile ejector slot cover locking cut rear end.
66	Profile ejector opening.
67	Profile cartridge clearance slot to shape at front end.
68	Profile cartridge guide cut on right side of cartridge clearance.
69	....
70	....
71	Profile cartridge guide wings at rear end of cartridge clearance slot.
71½	Profile radius on right side of cartridge opening.
72	Profile heading cut.
72½	Recut heading cut.
73	Recut rounded shoulder at rear of receiver.
74	Recut extractor clearance cut on inside of bolt bore on side.
74½	Recut extractor clearance cut on side of bolt bore on front.
75	Recut ejector clearance cut on inside of bolt bore.
75½	Spline mill ejector slot on front end of bolt bore.
76	Rough mill locking clearance cut at front end, finishing bottom shape and leaving 1-64 on shoulder.
77	Mill clearance slot at front of gear case lug.
78	Mill take down pin clearance slot.
79	Rough out locking slot.
80	Mill butt tang locking slot at rear end.
81	Mill lock butt tang stop shoulders.
82	Mill operating lug clearance on left side of cartridge clearance slot.
83	Mill butt tang clearance on right side.
84	Shave charging handle clearance slots.
85	....
86	Shave rear end of charging handle clearance slots on left side.
87	....
88	Profile bevel at rear end of ejector clearance slot.
88½	Shave ejector clearance at rear end.
89	Profile magazine catch in magazine boss.
90	Profile angles at front end of upper and lower locking lug clearance slots.
91	Profile rounded shape at back to fit bottom of butt tang.
92	Mill feed arm stop lug clearance slot.
93	Profile hinge clearance slot.
93½	Profile corner of front end of ejector cover slot.
94	Undercut front end of grip-slide cut.
95	Inspect after machine operations have been done.
96	File uneven surface off rear end and burr tops for polish.
97	Rough polish bottom side and top.
98	Corner edges of receiver and polish edges.
99	Rough polish.
100	....
101	Polish angular surface at right on cartridge clearance cut, gage bolt bore, break inside corner and file cartridge clearance cut.
102	Polish extractor clearance cut and safety-slide.
103	General inspection after first polishing operation.
104	Grind face end.
105	Lap large hole to size.
106	Gage receiver for bolt and rack.
107	Lap small hole and rack slot.
108	File safety-slide slot.
109	File ejector slot.
110	File receiver to fit ejector.
111	....
112	File and fit receiver to guard.
113	Broach guide rib.
114	File receiver to fit gear case.
115	File ejector opening.
116	File end of locking cut to fit feed cover.
117	Finish platform of feed arm clearance cut.
118	Machine rear cartridge guide wings.
119	File top of receiver and break corners at front end of ejector slot.
120	Fit charging handle, gage, and corner rear end.
121	File top to gage.
122	Mill barrel thread at front end.
123	Profile off end of barrel thread.
124	Roll stamp name.
124½	Roll inspection stamp.
125	Scrape out barrel end after threading.
126	....
127	File and qualify front end after threading.
128	Finish bolt lock up on receiver.
129	Finish locking slot to size.
130	Match receiver with feed cover on outside shape.
130½	File and emery receiver to match receiver.
131	File receiver to fit locking piece.
132	File receiver to fit butt tang.
133	Number receiver.
134	Finish polish.
135	....
136	Grind magazine hub to gage.
137	Put in magazine center key and file to micrometer.
137½	Profile feed operating arm lock cut.
137¾	Profile magazine locating key-slot in magazine hub.
138	....
139	Hand tool recess clearance cut.
140	Squeeze in receiver at locking shoulders 0.006 in.
141	Harden.
141¼	Lap piston bore.
141½	Regage, fit rack, bolt bores, and feed cover.
142	Sand blast.
143	Brown.
143½	Qualify after browning (finish).
144	Grind lock up shoulder.
145	Assemble.

The fixture in which the receiver is carried on the turret-lathe spindle, is shown clearly in Fig. 19, and in the drawings Figs. 20, 21 and 22. It will be noticed that the receiver forging is secured in the fixture by setscrews at the side which hold the work in a channel formed in the top of a swiveling plate *D*, Fig. 20, while two other screws through the top of the fixture act downward upon the flat face at the top of the forging.

The receiver forging measures over all 11⅝ in., and



FIGS. 22 TO 24. A NUMBER OF THE FIXTURES AND TOOLS USED

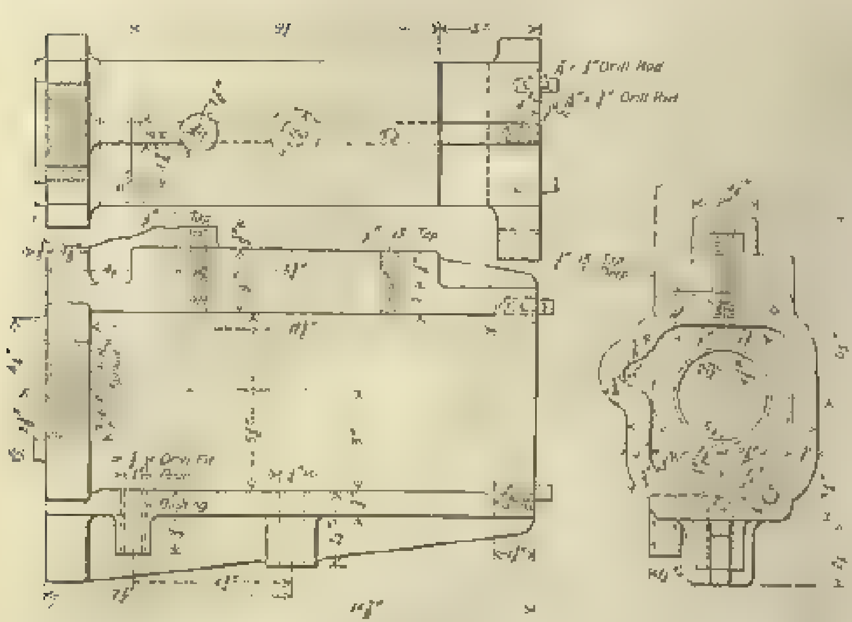


FIG. 21. COMPLETE DETAILS OF ONE FIXTURE USED

it is obviously impossible to put the hole through from one end with satisfactory results. Instead of attempting this with the probability of the drill running out of truth before it has reached the rear end, the swivel table *D* was provided in the design of the fixture, enabling the hole to be drilled halfway through the swivel table and work turned end for end and the remaining half of the hole drilled from the front. The drawing shows the method of mounting the swivel table with a cone-headed, central stud, and the means of locking it by an index pin at the back of the fixture which enters hardened and ground bushings fitted into the bottom of the swiveling plate. The spot drill, long drill and reamer operate through the bushing carried in plate *E*, Fig. 20, in the front end of the fixture. This bushing plate is provided at diagonally opposite corners with two $\frac{1}{16}$-in. hardened bushings which fit over dowel pins in the face of the fixture more clearly shown at *E*, Fig. 22. When the bushing plate is slipped into place it is held by two screws with flatted heads which require only a quarter-turn to clear the slots in the ends of the plate and allow the latter to be removed. The fixture just described is accurately constructed and carefully counterbalanced, and the operation of drilling and reaming the hole is performed carefully to insure as accurate results as possible, particularly so far as concerns the straightness of the hole.

The actual diameter of the bore is not of prime importance at this point as several reaming and lapping operations are performed later with other equipment. The spotting drill and through drill are kept ground accurately on the lips to assure truth in starting and drilling, and feeds and speeds are adjusted to preserve the greatest degree of accuracy obtainable in the drilling and reaming process. The reversing of the work end for end by means of the swivel plate, is a test of the accuracy of the fixture, and the fact that the hole drilled half-way through the receiver from each end and then reamed clear through will test out properly for straightness and size when a long standard plug gage is slipped clear through, is a proof both of the good workmanship in the fixture and of the care taken in drilling and reaming the receiver.

After the receiver leaves this fixture it is placed in another fixture on a gun-barrel reaming machine where the hole is still further enlarged by two machine reamers. A hand reamer, Fig. 23, is then put through the work for the final reaming operation, this leaving about 0.001 in. to be removed by lapping. The limit gage to which the hole is lapped is shown in Fig. 24. The small end of this gage has a diameter 0.905 in., the large end is 0.906 in., the tolerance therefore being 0.001 in.

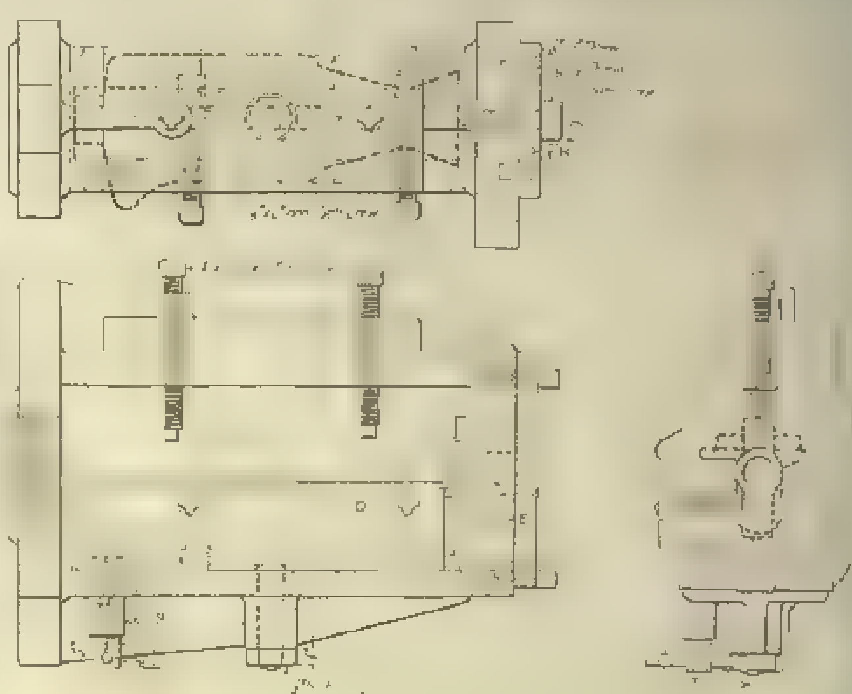


FIG. 20. SWIVELING FIXTURE FOR THE TURRET LATHE

This gage is made of three pieces. The handle or body is a 3½ in. length of hexagonal cold-rolled steel, ⅞ in across flats, with a hole in each end made to a taper of 0.05 in. per in. In these holes fit the taper shanks of the limit gages proper, which are made of tool steel hardened, ground and lapped. A $\frac{3}{16}$-in. hole is drilled crosswise through the handle at the bottom of each taper hole to allow the gage ends to be drifted out for replacement or other purpose.

Lapping the Receiver Hole

The method of lapping the main receiver hole is illustrated in Fig 25. The work is held in a fixture on a gun-barrel machine in similar manner to the set-up for machine reaming. As in the case of the reaming operation two receivers may be lapped at the same time. The laps used are of the "cat tail" form, the lead lap on the end of the long shank being about 5 in. long. The lead is cast on the end of the rod and is split for the insertion of a thin pine adjusting wedge. Emery and oil are used on the lead body for a lapping medium, No. 36 emery being used for roughing and No. 60 emery for the finish lapping.

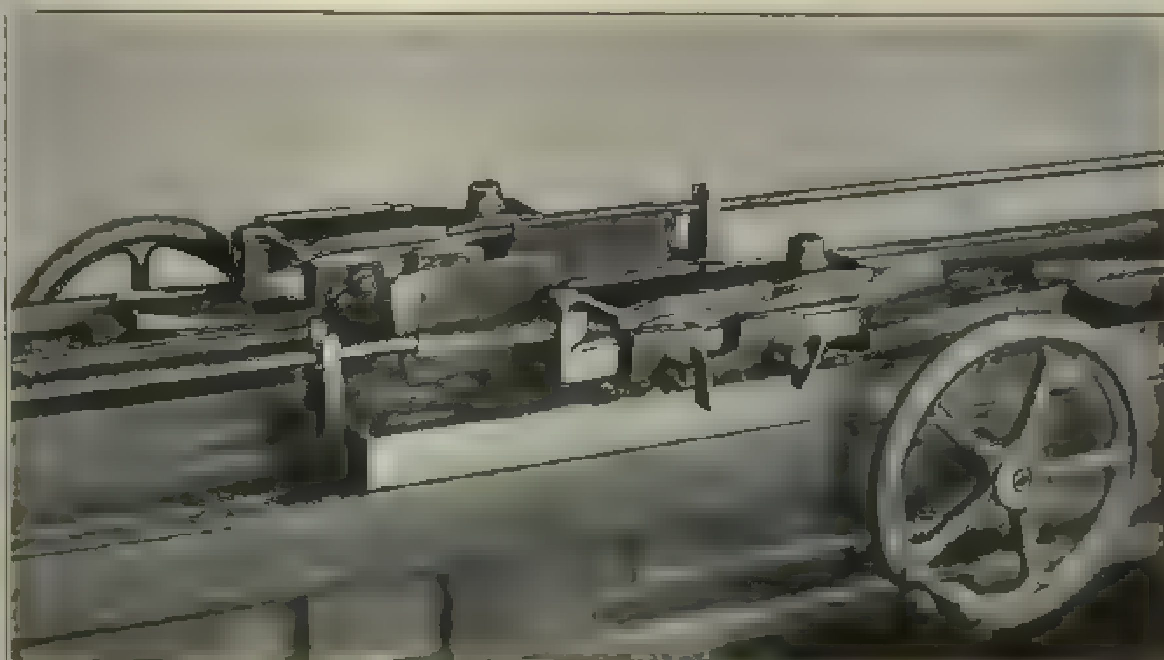


FIG. 25. LAPPING RECEIVER HOLE TO SIZE

An Early Form of the Famous Caterpillar Tractor

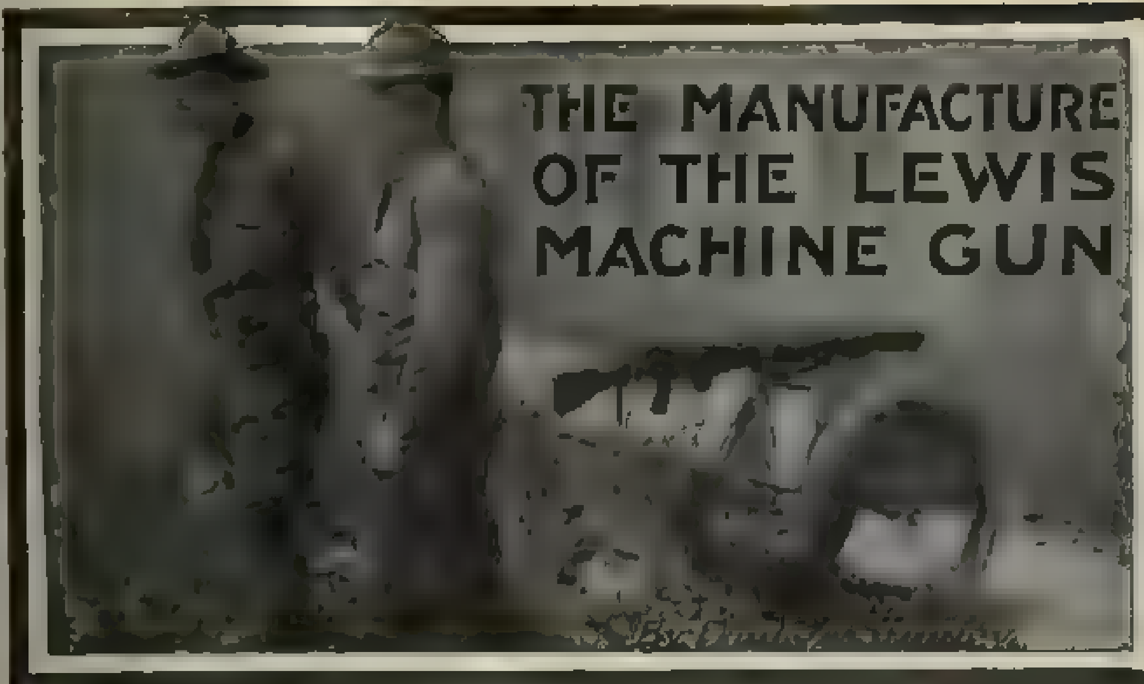
By W. D. Forbes

In an article on page 20 "Anent Our Fortieth Birthday," your devil—I suppose there is still a devil—made me say that the articles by an Englishman in America were to be found in the *Locomotive Engineer*, when I really said they were to be found in the issues of *Engineering* of 1870, '71, '72, and as they are well worth reading I call your attention to the devilish performance.

In thinking over the life of the *American Machinist* I call to mind something which I believe must have been very near the original idea of the now celebrated war tanks. I returned to America from working in various continental shops, to find that those in America differed in many ways from them; so I went to work at Delamater's shops at the foot of West 13th St., New York City. My work was in a huge wooden building on the south side of the street and Mr. Miller was the foreman. During my first noon hour I noticed a group of men around a platform which was perhaps 12 ft. long and half that width and on it were mounted four wheels around which were belts—chain belts I think—and to these belts were fitted posts or pillars about a foot apart; these posts were of course radial as they passed over the wheel and vertical between them.

The inventor whose name I cannot recall, had a broken arm; he and a couple of men pushed on the back of the platform and it moved along the floor laying its own tracks, so to speak; or perhaps more properly: laying its points of support. I think the idea of it was to make a traction engine, but I did not stay long enough to see it completed. As this was in the winter of 1874 I think, it must have been one of the very earliest of this type of motor. As I remember, a Baxter engine and boiler was to be the motive power. Perhaps if there are any left of the old Delamater association some further details of this, to me, interesting machine could be obtained. H. B. Roelker, 41 Maiden Lane, was I think chief draftsman for Delamater at that time, and he might recall the circumstance.

I saw John Ericsson looking at the machine with his draftsman, Mr. McCord, who later became professor of mechanical drawing at Stevens Institute of Technology, Hoboken, N. J.



III. The Receiver—II

Important operations covered in this instalment include the drilling, reaming and lapping of the small hole or piston bore, the gaging by the holes to test for parallelism, the finish-facing of the ends in the turret lathe, counterboring and recessing for the locking shoulders; finish-milling of the bottom and length-milling of the platform surface. Details are given of machine and hand operations, and of methods of testing and gaging at various points.

THE drilling and reaming of the small hole or piston bore through the receiver, is accomplished on the turret lathe with tools illustrated in Figs. 26 and 27.

The tools consist of a set similar except for size, to those employed in boring the large hole in the receiver as described in the first section of this article. The spotting drill, through drill and machine reamer are seen in the turret toolholders, Fig. 26. The method of locating and holding the receiver will be understood upon examination of the illustration and the line engraving, Fig. 27.

As has already been stated, the large hole through the receiver constitutes the working point and locating medium by which all subsequent operations are positioned and to which various surfaces machined must bear a positive relationship.

In Figs. 26 and 27 is brought out the manner in which the large receiver hole is first made use of for locating the forging for other operations.

Fixture Details: Referring to the line drawing, Fig. 27, it will be seen that the turret-lathe fixture there shown carries a long, hardened and ground arbor which is offset from the center of the fixture and which is used to locate the receiver positively for boring the small hole at the correct location. This locating arbor has a long, straight shank fitting snugly in the head of the cast iron fixture and further secured by a ¼-in. pin driven crosswise through the head and shank as indicated in the drawing, Fig. 27. The arbor has a shoulder of liberal diameter which seats squarely against the face of the fixture head, and the outer end of the arbor is reduced in diameter so as to enter a hardened and ground bushing which is pressed tightly into a machine-steel guide plate located by dowels at the front end of the fixture. The guide plate is further held to the fixture by a wing-head or flatted-head screw which when given one-quarter turn to align with a slot in the plate, permits the plate to be removed or replaced.

In the head of the fixture at A is a centrally located plug, which fits into a bushing in the fixture bore, both plug and bushing being of tool steel hardened and ground. The handle of the plug is knurled, and the exposed body portion of the plug is ⅜ in. long. When the receiver comes to this fixture with the large hole finished as previously described, it is ready to be placed over the locating arbor B for the drilling and reaming of the small hole or piston bore; and as this hole like the other is drilled half-way from each end, the short locating plug A must be removed from the fixture for the operation of boring the first half of the hole. With the receiver slipped over the long arbor B, it is located to bring the second hole into central position in the body of the metal by the two vertical-gage plugs C, whose lower ends bear upon the upper surface of the receiver platform where the work is rigidly held against twisting on its arbor by setscrews D, located crosswise at the front of the fixture.

The small hole may then be put in part way with the

turret tools, and afterward the work may be reversed end for end, with the short locating plug *A* in place in the fixture, that in the completion of the piston bore in the turret lathe, the receiver may be positively located at the inner end by this auxiliary plug. This procedure brings the two holes in line, and with their centers at the right distance apart.

It will be seen that there are two bushing plates for the front end of the fixture; one of these plates with its guide bushings and dowel-pin bushings being plainly shown on the turret in Fig. 26. The bushing plates are readily changed, the dowel pins which located the plate on the fixture being of unequal length, so that in putting on the plate it starts over one pin first, and thus is guided part way into place before the opposite pin enters its bushing at the other side of the plate.

As in the case of the larger hole in the receiver there are several subsequent machine- and hand-reaming operations in the small bore, the machine-reaming being accomplished in the gun-barrel machine. A detailed drawing of the hand reamer is given in Fig. 28.

Referring again to machine reaming, Fig. 29 is presented at this point to show the fixtures and reamers for this work. Two fixtures will be seen on the gun-barrel reaming machine; one with a receiver in place, the other empty to show the method of locating the work by means of plugs.

At the rear end of the open fixture will be noticed a fixed plug which is in line with the knurled-handle removable plug in the front of the fixture. At the back and directly beneath the fixed plug there is a guide bushing for another removable plug, which in this view is taken out of its seat. When the receiver is placed in the fixture, the end of the large hole goes over the short plug at the rear of the fixture and the knurled plug in front is slipped into the other end of the bore. The knurled plug at the rear of the fixture is then slipped through into the smaller hole, which is to be reamed, which holds the receiver correctly while thumbscrews at the side are set up against the receiver body, after which the lower plug at the rear of the fixture is withdrawn, leaving the small hole clear for reaming from end to end.

After this machine-reaming operation, the hand reamer, Fig. 28, finishes the hole.

Putting through the two holes in the receiver is a most exacting process. Given a single piece of work of this character and length with two holes to be finished straight from end to end, of exact diameter at all points, to dead-center distances apart at each end, exactly parallel to each other in all places and without twist or deviation, a good toolmaker would consider it a task calling for a high degree of ability and workmanship. The manufacture of such work in large quantities is a mechanical undertaking that cannot be fully appreciated without first-hand observation and study of the methods and equipment that make it possible. It will be understood that shop operations of this character cannot be conducted satisfactorily without the most careful workmanship and closest degree of inspection at various stages, with the aid of accurate systems of gaging.

Some of the gages used during the boring and finishing of the receiver holes are illustrated in Fig. 30. Both large and small holes are tested for diameter and straightness by long standard plug gages which must

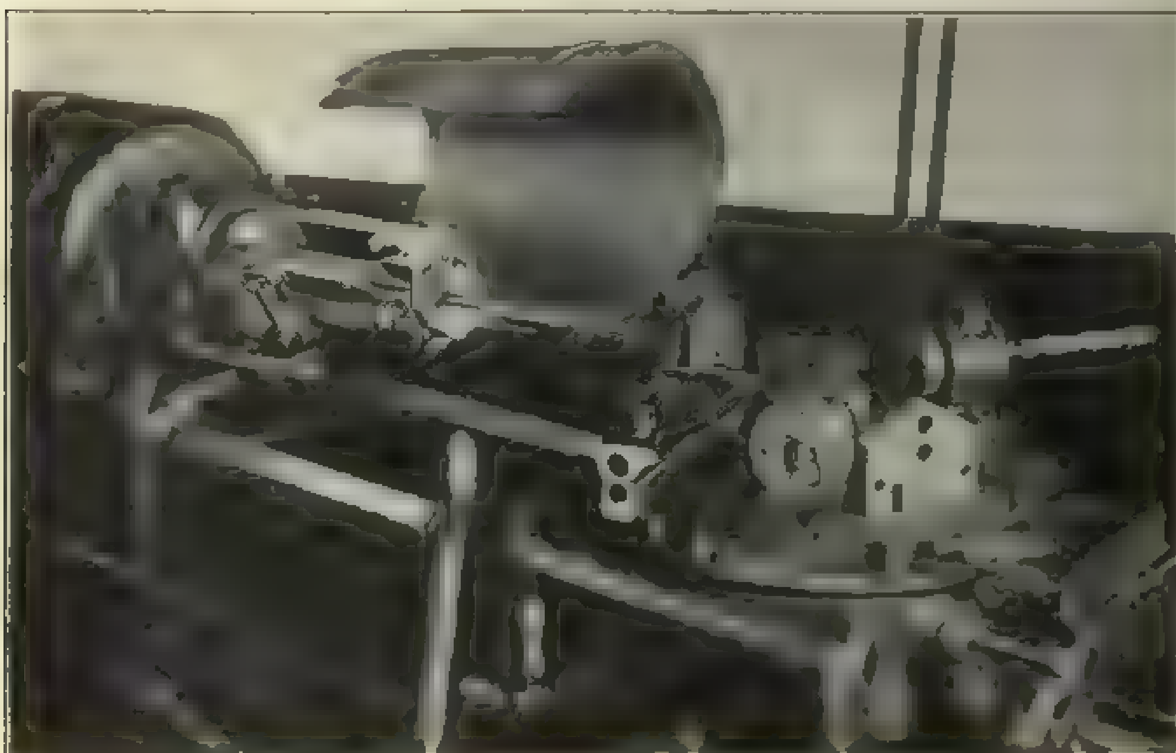


FIG. 26. DRILLING AND REAMING THE SMALL HOLE IN THE TURRET LATHE

pass through the entire length of the bore. One of these long plug gages may be seen in the small hole of the receiver near the front of the bench, in this engraving. The gages for testing the center distance between the holes at each end, consist of two standard plugs located on exact center distance in one gage body

Two of these combined gages will be noticed on the receiver. With this test, if the holes are out of parallel by even the small part of a thousandth of an inch, the thin gages as feelers under the smaller plugs will immediately disclose the inaccuracy.

This test, it is interesting to note, is not confined alone to the inspection of the receiver after the small hole has been finished to size. Instead the work is

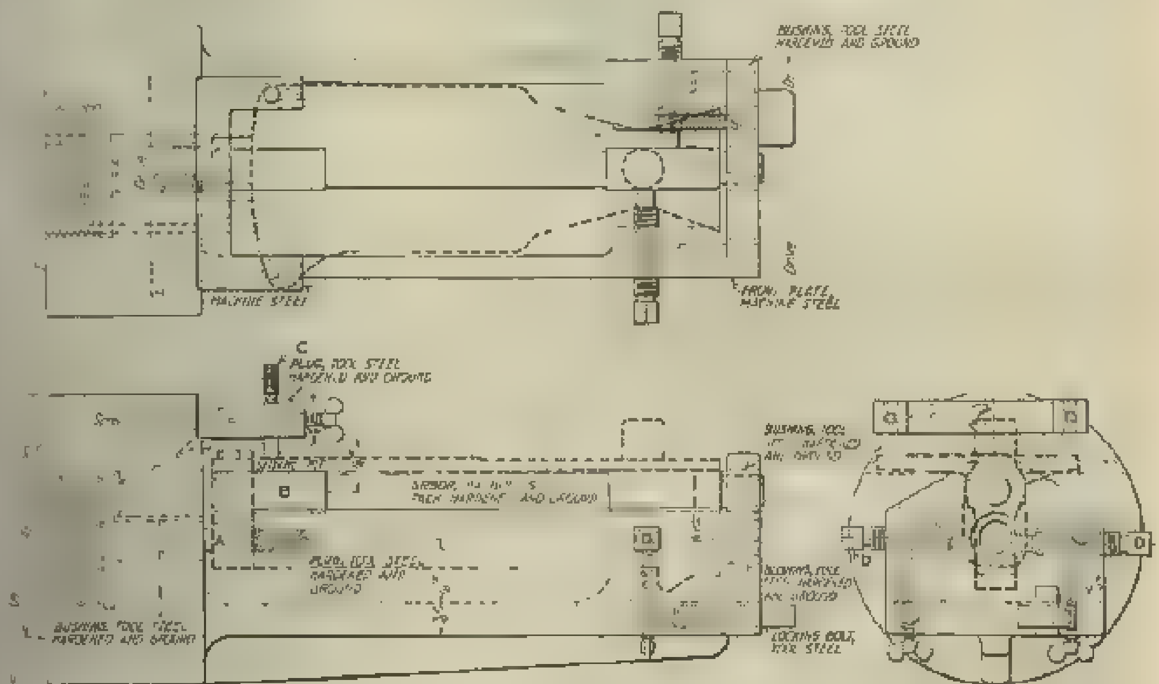


FIG. 27 THE TURRET-LATHE FIXTURE

surface plate, one of them with the plugs entered into the receiver holes.

It is quite conceivable that if tested with these gages, only, the center line of one hole might deviate from the plane through the other center line, or the two lines might cross one another at some point in their lengths and nevertheless the fixed plugs would enter properly at both ends assuming the correct-center distance was maintained at the mouths of the holes

In other words the bores might fail in parallelism with one another without the discrepancy being detected by the center-distance gages alone. Because of this a rigid test for parallelism is applied, which in conjunction with the test just referred to, assures positive accuracy in respect to the foregoing conditions

The Parallel Test

This test is illustrated in the instance of the receiver shown set up between the blocks on the surface plate. Straight test plugs are placed in both holes with the ends of plugs projecting from both ends of the receiver and the work then rests with the large plugs bearing upon the tops of the two blocks on the surface plate. These blocks are ground to uniform height and their tops form a plane surface upon which thickness gages are placed to test between the small plugs and the blocks. The thickness of these thin test gages added to half the diameter of the small cylinderical plugs, is equal to half the diameter of the large plugs in the main bore of the

tested in this way at various times during the several processes required in machining the bore. As has been stated, several reaming operations have been applied preliminary to lapping, and all through these stages the accuracy in this respect is checked up by this bench test.

To make this possible, complete sets of test plugs are

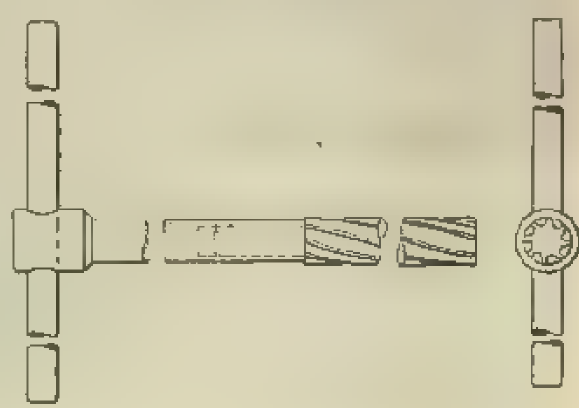


FIG. 28 DETAIL OF HAND REAMER

lapped up in pairs, varying from one pair to another by very minute increments, and these plugs are kept in the cases shown in Fig. 30, so that as the work proceeds, a set of plugs may be selected for fitting the holes and applying the test as represented.

Any discrepancy discovered during these intermediate tests may be corrected in succeeding reaming and lapping operations. In this manner when the final lapping process is concluded, the two holes through the receiver test out accurately in all respects

Another feature of the inspection of the receiver on the bench plate is the application of the upright-angle plate or square shown behind the forging in Fig. 30 With the work supported on the plugs as illustrated, the perpendicular edge of the square is brought against the face of the receiver platform to determine if the forging will clean up properly and evenly in the milling and profiling operations that follow. This is merely a safeguard test to eliminate unnecessary work in later operations, and forms a means by which the adjustment of the turret-lathe boring fixtures may be regulated for differ-

FIGS. 29 AND 30. REAMING AND TESTING OPERATIONS

FIGS. 31 AND 32. FINISH FACING THE ENDS AND SOME OF THE COUNTERBORING AND RECESSING TOOLS

ent lots of forgings, that the metal to be afterward milled off may be apportioned properly in relation to the bored holes.

The ends of the receiver forgings are roughed off at the outset with straddle mills as described in the preceding section of this article. After the holes have been bored through and finished, as referred to above, the ends are finish-faced square with the holes in a tur-

ret-lathe operation shown in Fig. 31. That is finish-faced so far as concerns cutting-tool processes, for they are eventually finished dead to length by a grinding process in which a few thousandths of an inch is removed with the wheel.

The turret-lathe fixture and facing tools are clearly represented in Fig. 31. Here the receiver is mounted upon a central locating arbor carried in the fixture head which is screwed on the spindle nose, the arbor fitting snugly in the large hole of the receiver. Another short plug in the fixture enters the small hole in the receiver, and a projecting lug on the fixture is adapted to act as a driver and further to steady the work. Two facing cutters are mounted in the turret, each with a pilot to enter the end of the large hole; and the depth to which these cutters can work is positively determined by a rigid stop-bar projecting from the middle of the turret-slide and abutting a large adjustable stop-screw tapped into the front of the head of the machine. With this arrangement it is obvious that the facing tools can work only to the predetermined point, no matter what degree of pressure may be applied to the pilot wheel, as the stop-bar provides a rigid strut between turret-slide and head, and undue pressure of the turret-slide forward, would merely be transmitted directly to the head; then acting upon that member as a whole, further cutting action of the tools upon the end of the work would be prevented.

It has already been stated that after the holes are put through the receivers, the fixtures in which they are later machined are so designed as to serve as a gage and check upon the accuracy of preceding operations.

Thus in the fixture, Fig. 31, the two locating plugs in the head of the fixture, themselves form a gage for the holes in the receiver and for the center distance between these holes. Both ends of the receiver are faced in the same manner. The front end, that is the one shown under operation in Fig. 31, is the important end-surface by which the receiver is located for end-position in other fixtures and operations.

The height gage shown on the stand to the left in Fig. 31 is used to test the length of receiver as faced off in this operation. The gage consists of a heavy baseplate carrying two vertical posts. One of these is really a hardened and ground vertical test plug, lapped off at the top to the standard height of a receiver when completely finished; and over this plug the receiver taken from the turret lathe is slipped, as shown for the application of the test for length over all. This test is made with a dial gage supported by an arm on the post at the rear. The gage is swung over the vertical plug for setting and then swung back into contact with the receiver end, to test its height over all from the gage base. Whatever allowance is desired for end-grinding can thus be provided for under this test.

After the receiver has been faced on the ends it is ready for the recessing of the grooves in the larger hole and for counterboring the front end operations, which are performed with the turret tools in Fig. 32. The fixture for this work holds the receiver in the same way

FIGS. 33 AND 34. GAGE FOR A RECEIVER BOTTOM AND THE LENGTH MILLING OPERATION ON THE PLATFORM

as the work is held for the end-facing operation; a central locating arbor being part of the apparatus as in the other case. The counterbore and the recessing tools are provided with substantial, adjustable stop-collars for positively determining the depths to which the tools are to be operated.

One of the counterbores which enlarge the front end of the hole for the fit of barrel and thread, is shown in line with the work in the illustration. The two recessing tools which form the locking grooves near the middle of the length of the bore, are in place in the turret directly in front of the observer. These tools have to be run into the hole a distance of over 5⅜ in. for the cutting of the recess, and when in place with stop-collars against the front end of the receiver, the recessing cutter is fed into the metal by a movement controlled by the handle seen just behind the collars. The locking shoulder formed by this cut must be exact in position from the front end of the receiver, and the recessing tools are so adjusted as to leave a small amount of metal to be finished later by an internal grinding operation.

After this work of counterboring and recessing has been done in the turret lathe, Fig. 32, the receiver is taken to the bench, and hand tools of similar nature to those in the turret are applied for scraping out and touching the shoulders to insure these cuts coming to gage. A very complete set of gages is used in connection with the work, and these testing tools are shown in their case in Fig. 32.

We have got to win this war

The method of keeping these gages in recesses formed in a wooden frame or case, is generally employed for tools of this character throughout the different departments. There is a definite place for each gage of the set, which is indicated by a stamped aluminum plate secured opposite each pocket, and the case thus forms a convenient device for handling a set of gages in a manner that leaves little possibility of any of them becoming misplaced or lost.

The set of gages shown, includes limit plugs for the counterbored openings, depth gages for the counterbored shoulders, etc. The micrometer gage at the right is a length-rod for testing the position of the locking-shoulder recess in the larger hole.

This has the usual micrometer head and cross-bar for depth gaging, while the spindle carries a long auxiliary spindle with enlarged end for contacting with the shoulder formed by the recessing tools. Other gages of an interesting nature are included in the set each for its specific purpose and all made to a high degree of refinement.

The receiver now passes through some important milling operations in which a number of interesting fixtures and milling devices are used. In the first of these milling cuts the bottom of the receiver is surfaced and the spring-case lug at the front end of the bottom surface is formed to shape. The nature of this cut will be understood upon reference to Fig. 33, which shows the gage for testing the bottom cut and the contour of the lug.

The gaging fixture locates the receiver bottom up, by a long arbor which is slipped through the large hole, and by a short plug which enters the front end of the small hole. The front end of the receiver is held against the inner face of the left-hand upright on the fixture, and the contour gage for the lug is then pushed down over the work to test the lug outline. The flat gage for this purpose is fixed in a round plug which is moved up and down in its seat in the fixture head, by the small knurled-head spindle above. This spindle has a shallow flat notch in its side, the lower edge of which comes flush with the top face of the gage head when the lug being tested is of correct height. The two small plugs at the right of the lug gage are flush pin gages for testing the accuracy of the finished portion of the receiver bottom, immediately adjacent to the lug.

These flush pins when slipped down into contact with work finished to the exact height, have their upper ends dead flush with the flat surface of the head in which they are carried. The pins are moved up and down by small cross-pins fitted near the upper ends of the flush pins, and they slide in vertical clearance slots milled part way down the head. It may be stated here that flush pin gages of various types are used extensively throughout the plant, and several illustrations of such tools will be presented later.

The next machine operation on the receiver is the milling of the top of the platform which is accomplished in the machine shown to the left, in Fig. 34. The platform surface to be milled is in the general form of a flat ledge extending in U shape from the back of the receiver to a point about midway of the length of the forging.

The work is held in its fixture by locating plugs and clamping device through the holes, so that the top surface of the platform is milled parallel to the main hole. A plain milling cutter is used in the operation.

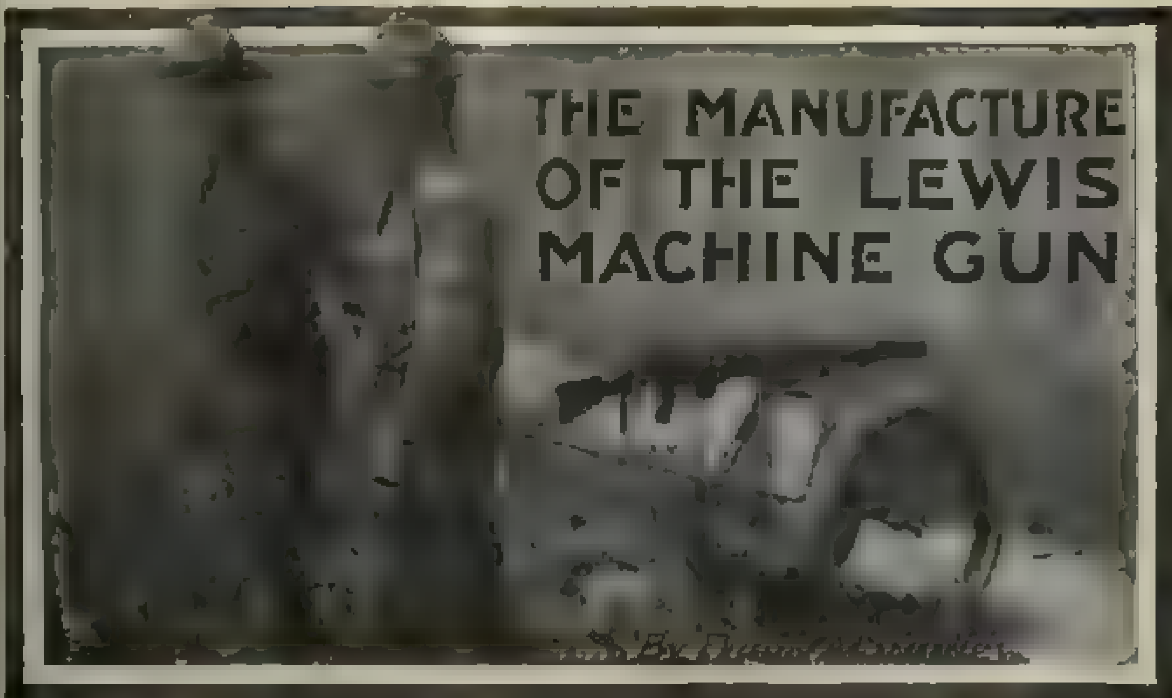
Aircraft Inventors to Submit Ideas

The National Advisory Committee for Aëronautics issues the following statement:

All parties desiring to bring to the attention of the Government inventions pertaining to aëronautics, or suggestions for improvements of existing types of aircraft and their appurtenances, are requested to communicate with the National Advisory Committee for Aëronautics, Munsey Building, Washington, D. C., and to submit comprehensive outlines of the proposed devices, together with necessary drawings, data, and the results of tests, if tests have been made.

All such suggestions and inventions are considered confidential, and where devices or suggestions of merit are submitted they are referred to the proper officials with suitable recommendations.

Attention is called to the fact that many devices and proposals are submitted by persons unfamiliar with the principles and practices involved, hence such parties desiring to submit plans or devices should, as far as possible, secure competent scientific and technical advice.



IV. The Receiver III

Milling and profiling processes are here dealt with following the broaching of a long seat at the bottom of the piston bore which is cut out with roughing and finishing broaches dividing the work between forty cutting teeth. Details are included of a gaging fixture fitted with flush fingers in place of flush pins which cannot always be applied to surfaces that are undercut or otherwise partially obstructed by projections.

THE first operation to be considered in this section is the broaching at the bottom of the small hole to receive the rack which is attached to the piston and which carries the striker.

Two broaches, one roughing and one finishing, are used in the cuts. These tools and the method of operation are illustrated in Fig. 35. Both of the broaches are long affairs with shanks that fit snugly in the small hole of the receiver. There are twenty teeth on each broach with about 1-in. space between teeth. The depth of cut distributed over the entire series of teeth means about 0.0015 in. cut per tooth. The ends of the broach shanks are slotted crosswise for a key, and the broaches are drawn through the work in the manner indicated in the illustration.

Further Milling Cuts

Following the broaching operation there are numerous milling and profiling processes, and a few of these will be illustrated to show certain types of fixtures and gages and some of the work accomplished by their aid.

The operation shown in Fig. 36 is straddle milling of the under side of the receiver table on both right and left sides. This work is accomplished with inserted tooth cutters secured to the ends of short, rigid arbors. The receiver is located in the fixture by the large hole and by a short plug entering the front end of the small hole so that the receiver-table surfaces may be milled in correct relation to the two holes referred to. Additional support immediately under the surfaces operated on is provided by the cam-shaped rockers at the sides, which are held in contact with the bottom of the work by means of the setscrews shown at the side of the fixture.

The gage for testing the correctness of the milling operation is shown at the front of the machine in Fig. 36. The method of holding the receiver in the gaging fixture by means of through plugs is clearly represented in the illustration. The gage carries four pivoted arms, in each of which is fitted two flush-pins which come in contact with the milled surface when the arms are pressed down by the fingers. In this test, with the arms pressed downward, all of the gage-pins are flush at their upper ends with the top surface of the arms if the work is correctly machined.

Flush-pin Gage

Each flush-pin is normally pressed downward a short distance by a sensitive spring so that there may be no tendency to stick at the uppermost position and so necessitate pushing down individually before each test can be applied.

The several receivers seen in Fig. 36 are represented with a narrow groove milled nearly the entire length of the bottom of the receiver; this groove having been cut in an operation preceding the milling of the table bottom, as illustrated in this view. This groove, or channel for the guard is gaged for depth in another interesting flush-pin fixture shown in Fig. 37.

This gaging fixture holds the receiver in the same manner as the gage in Fig. 36. It is provided with two sets of flush-pins, three in each set, the middle pin in

each set of three gaging the depth of the cut, while the two outside pins contact with and test the bottom of the receiver body itself so that the depth of the channel is represented by the difference in length between the central and outer flush-pins.

Fixture for Milling at an Angle

One of the interesting milling cuts made before the receiver is ready for going to the profilers is the forming of the ejector clearance slot, which is accomplished with the aid of the fixture shown in Fig 38. The clearance slot is milled through the top of the receiver. Further operations in connection with the ejector clearance slot are performed under the profiler.

The fixture here shown is of special interest as it brings out clearly the method of locating and holding the receiver by plugs fitting the two holes, an arrangement characteristic of the whole series of tools employed on receiver work. The two plugs in the right end of the fixture are for the front of the receiver, and the work is here located, as in other operations, by its ends *E* and *D*, which are held in contact with the stop shoulders on the locating plugs by means of the shouldered plug at the left end of the fixture, this latter plug being slid forward and held positively by the handle *A* which works in a slot *B* formed crosswise in the carrying sleeve *C*.

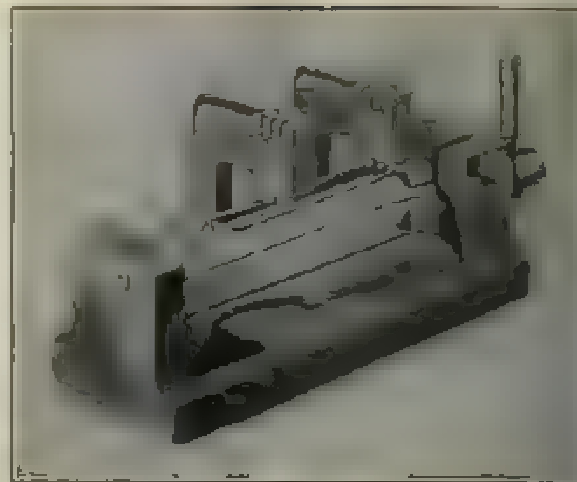


FIG. 37. GAGE FOR TESTING GUARD SEAT

Each of the three hardened plugs is finished to 0.001 in. under the standard size of the holes in the receiver. The two plugs at the right which tilt the work to the desired angle for performing the operations are located at the exact center distance apart of the large and small

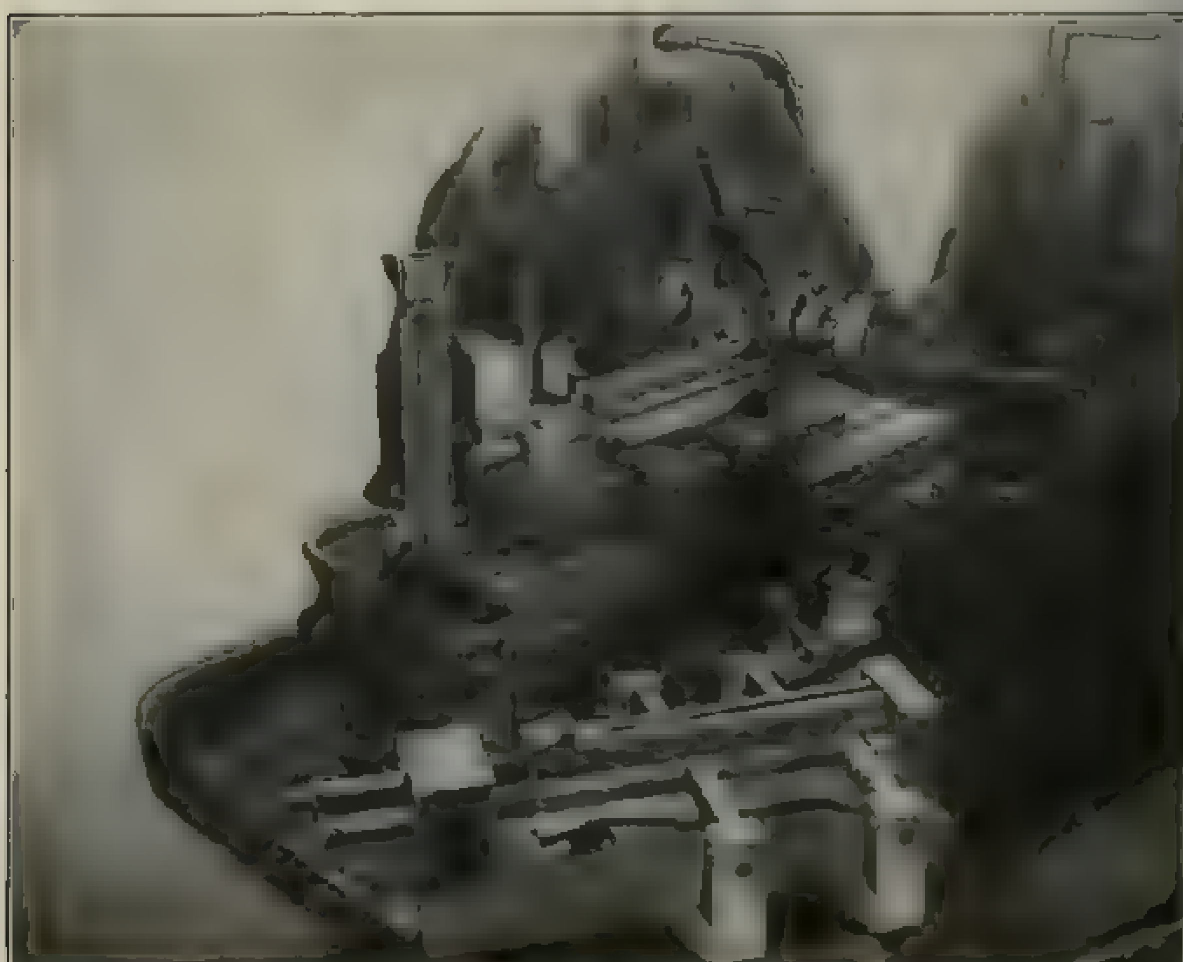


FIG. 36. STRADDLE MILLING UNDER SIDE OF TABLE

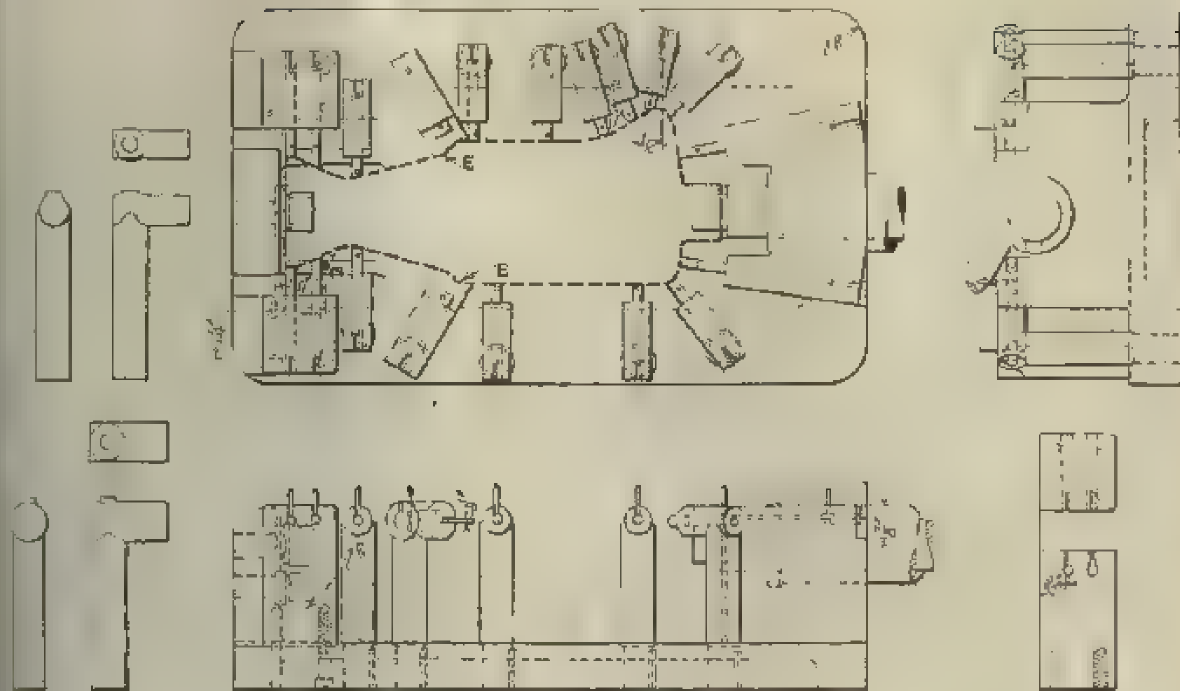


FIG. 40. GAGING FIXTURE FOR RECEIVER CONTOUR

holes which are lapped through the work. With the fixture in closed position, as illustrated, the shoulders on the opposite plugs come to a distance apart, corresponding exactly to the over-all length of the work. Like other tools used in the sequence of operations, this fixture gages the work that has gone before.

The first profiling operation, which is one of some 40 or more performed in the profiling machine, is illustrated in Fig. 39. This represents the profiling of the full outside shape of the receiver, a process in which there are really two similar operations in duplicate fixtures, one for roughing, the other for finishing. On both profilers

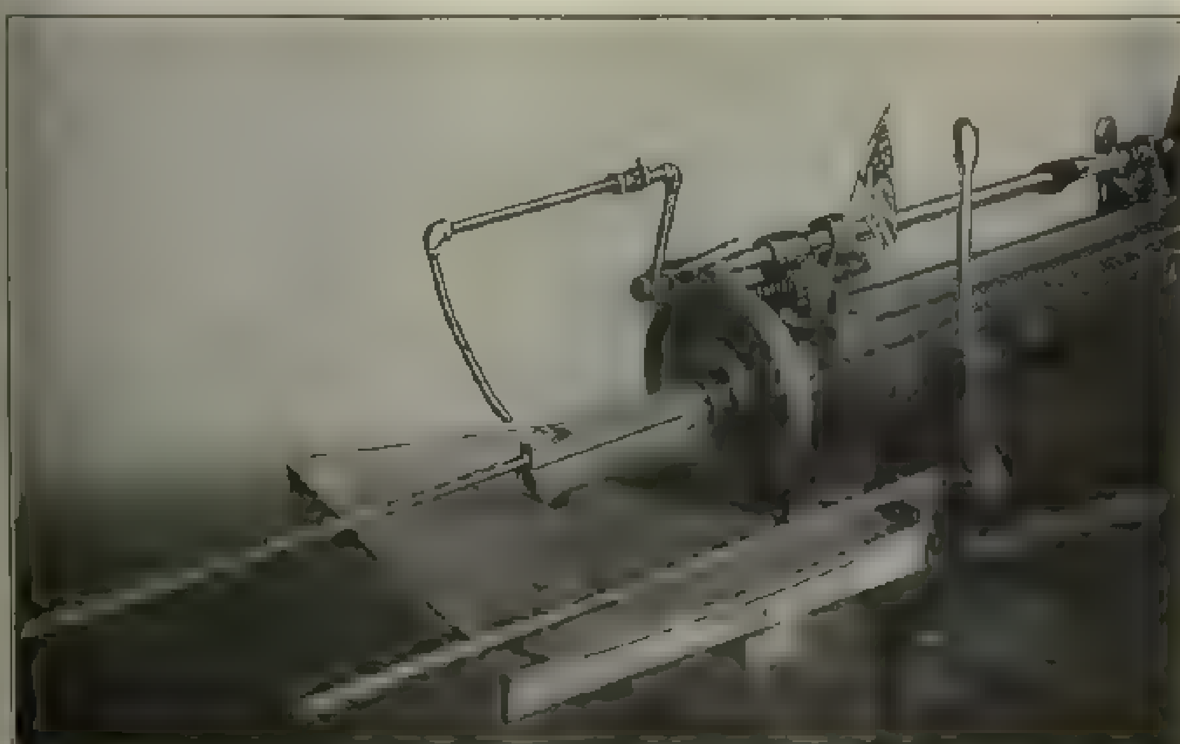


FIG. 35. BROACHING THE SEAT IN THE PISTON BORE

two heads are used, one for roughing and one finishing so that two separate cuts are taken around the work in each machine.

In Fig. 39 the profiling fixture is shown distinctly with steel-form plate and taper-guide pin at the right of the work. The method of locating and holding the receiver in the fixture involves the use of positively positioned plugs as in preceding tool designs.

The inspection of the profiled contour is accomplished in the gage shown on the stand at the right of the profiler, and is illustrated in detail in Fig. 40. This tool is a most complete flush-pin gage. It carries all told 19 gaging points, 17 of which are of $\frac{3}{8}$-in. drill rod, and two for the curved shoulders at E and E' are of $\frac{1}{4}$ x 1-in. flat gage stock. It will be noticed that several of the flush-pins are ground off at an angle at their front ends to suit sloping lines on the contour, while certain others are beveled off from each side to leave a contact point at the center.

In all cases the flush-pins are prevented from turning in their guides by small pin handles which slide in slots milled in the upright posts. These uprights are all bored out to uniform center height and are all fixed with their heads at the desired angle to the horizontal center line through the fixture by means of $\frac{1}{8}$-in. pins, or "dutchmen," driven into holes drilled half in the fixture base and half in the post bearing.

The lower ends of the posts are reduced to $\frac{3}{4}$ in. diameter, leaving a shoulder which rests squarely upon a seat formed in the fixture base, the seats for the whole series being all in the same horizontal plane and at the exact distance required below the center line through the locating plugs which carry the receiver. A fixture is illustrated in Fig. 42 for profiling the curved front end of the platform top of the receiver, finishing the locking-lug top at the end and profiling the rear end of the platform. This fixture serves for two distinct operations, the guide or form X being used for the front end and locking lug, and the form plates Y and Z for the rear end profiling. The construction of this fixture and the method of mounting the guide forms are clearly shown in the illustration.

A gaging fixture used in conjunction with the profiling fixture just described is shown in Fig. 43. As illustrated, this gage is provided with a series of flush-pins for testing the depth and positions of the various receiver surfaces machined in the fixture, Fig. 42. The points at which the different gage-pins bear upon the receiver will be seen upon inspection of the several views of the illustration.

Considering a little further at this moment certain features of the comprehensive system of gages developed for use on the Lewis gun parts, it should be noted that not all of the flush-gages are of the pin type, several examples of which have just been referred to. The general principle of flush surface gaging devices admits of much broader usage than would be feasible if the design were confined entirely to flush-pins only.

As an illustration: surfaces that are under-cut or otherwise partially obstructed by projections of one kind or another are out of reach of the ordinary flush-pin if carried in a fixed guide, and it is oftentimes a simpler and safer practice to apply some form of swinging gaging finger or lever than to mount a flush-pin in a sliding or swiveling holder which may be improperly set at some time and lead to inaccurate results. An illustration of a gage which brings out the application

FIG. 39. PROFILING OUTSIDE SHAPE OF RECEIVER

of flush-fingers in place of flush pins is presented in Fig. 83. This device is for gaging the position and shape of profile under the left side of the receiver platform.

The outline of the receiver in position in the fixture shows the points where the gage fingers contact with the work. There are three of these fingers, namely, ... two of them, ... and *B*, swinging in a horizontal plane and *C* having an up and down movement about its pivot. The fingers *A* and *B* are carved ... upper or contact ends to ... against ... or shoulders machined ... operation on the under side of the platform. When these surfaces are correctly machined and the ... ends of fingers *A* and *B* are against the work the ... surfaces near the outer ends will be perfectly flush with the vertical ... faces of the lugs *D* and *E* over which they swing. Similarly when gage finger *C* is brought into contact with the under platform surface, its upper face at the rear end should come flush with the top face of lug *G*. The gaging surfaces of projections *D*, *E* and *G* are ground off perfectly flat and true to correspond with the square edges of the gage fingers, and in making a test with these fingers the most minute discrepancy in the matching up of the surfaces is readily detected by the thumb-nail or the end of one's finger when passed over the joint.

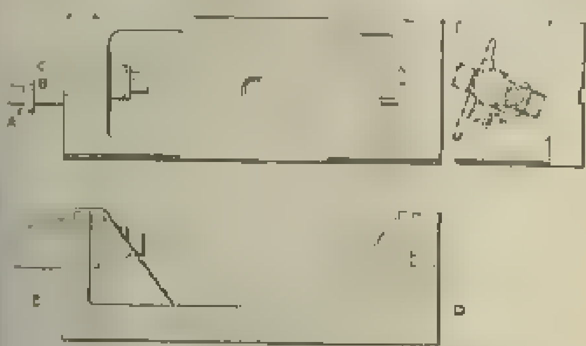


FIG. ... M... CLEARANCE GAGE

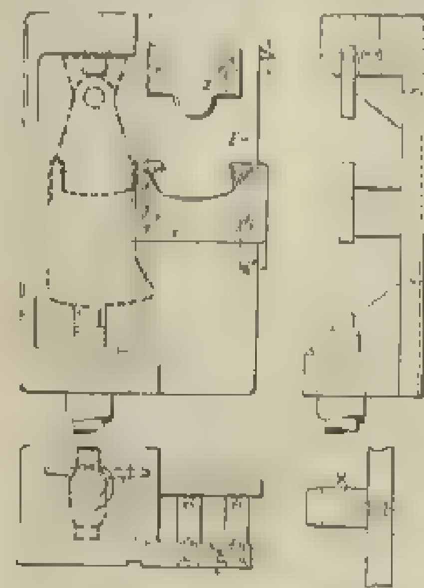


FIG. ... GAGE ...

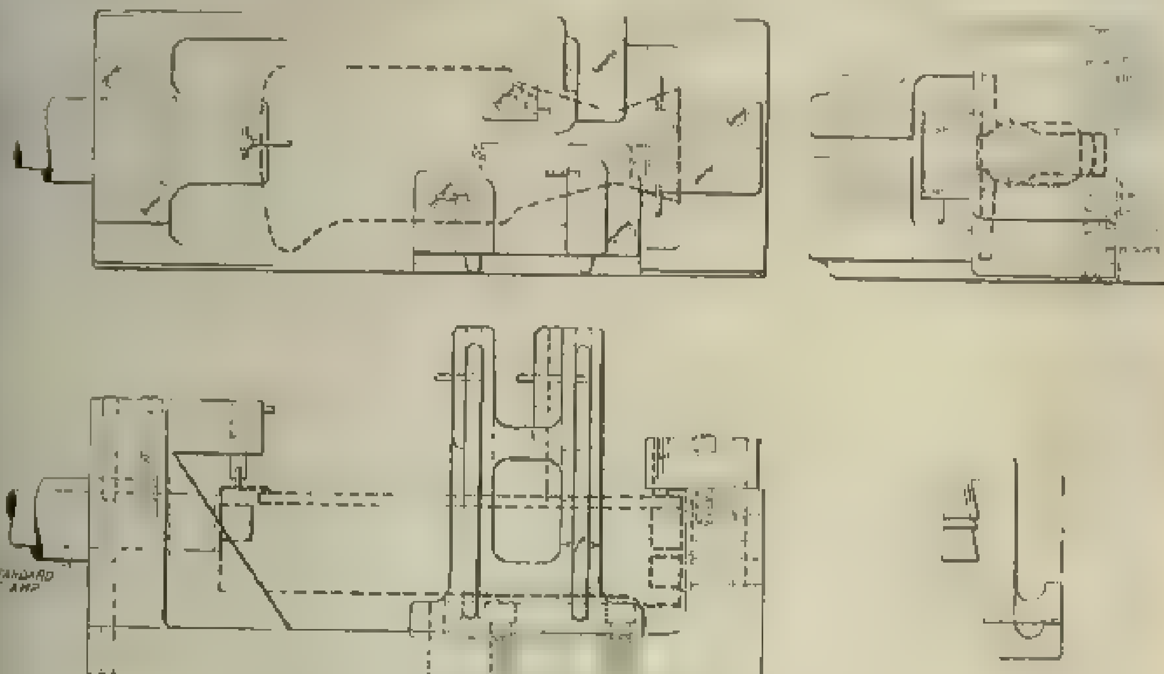


FIG. ... GAGE FOR ... OPERATIONS ON PLATFORM

It is possible of course, with this type of gage to derive an added advantage in the way of establishing an even more highly refined check upon a piece of work by incorporating the multiplying principle, using gage fingers with unequal length of arms so that the extended rear end of the finger will reveal any possible error

multiplied by two or three or more times its actual amount. This is often a great advantage where the limits are very fine.

In the gage illustrated in Fig. 44 no such multiplying

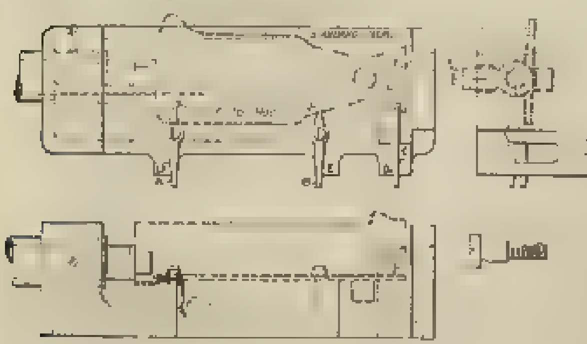


FIG. 44. GAGE WITH FLUSH FINGERS INSTEAD OF PINS

effect is essential and the contact and rear portions of the gaging fingers utilized are of practically the same length.

The Machine-Tool Market in Switzerland

By S. Lambercier

Previous to September, 1917, the rules governing exports from the United States were about the same for neutral countries as they were for the Allies, but since that time it has been necessary to obtain a Government license to export American goods to neutral countries. This embargo has had the effect of holding up shipments of goods previously purchased by neutral countries, some of which were at ports awaiting shipment or in transit thereto.

The intention of this embargo is to prevent exported goods either from reaching Germany or being in any way used for her benefit or for the benefit of any enemies of the Allies. While the Swiss importers understand and appreciate the wisdom of this intention on the part of the United States they are loath to believe it is intended to prevent all traffic with neutral countries.

Special Export Licenses

That this assumption is true, in part at least, has been proved by the issuance of special export licenses under sufficient warranties that such exports will neither be sold to enemies of the Allies nor be used for their benefit in any manner. Under such guarantees it has lately been possible for Switzerland to import small precision tools from the United States. This partial lifting of the embargo will help to maintain business connections between the two countries and has already resulted in considerable satisfaction to the Swiss importers.

So far as machine tools are concerned the question is more difficult of solution, as the Allies seem to believe that Switzerland can produce all the machine tools needed, and therefore their exportation to that country is not a necessity. This, together with the scarcity of cargo space in transatlantic steamers, makes it probable that machine tools will not be exported from the United States to Switzerland until after the end of the war. If this should be the case it will result in building up the business of the Swedish machine-tool builders, as shipments can be made from that country directly to Switzerland, Denmark, Norway and Holland, not to mention the central empire. Recently Swiss machine-tool importers have had numerous offers from Swedish manufacturers to sell and deliver their products to them.

Although German machine-tool builders have been busily engaged in supplying tools to their own government some of them have begun an active propaganda for the exportation of their goods and have done considerable advertising in Switzerland. With this in mind it would not be suprising if the German government would grant export licenses to ship German machine tools to that country, and for two reasons: first, by repurchasing such tools from Swiss firms they could safely export their own product from there to other countries under a Swiss name, and second, this would promote German industry to the injury of Swiss trade.

American Tools Costly

The price of American machine tools f.o.b. New York is very high, and when to this is added the excessive rate for ocean freight, insurance and transportation from the port of entry to Geneva the price becomes enormous. Nevertheless in spite of the high prices the Swiss shops do not hesitate to buy American machine tools as they know their value and will wait from 12 to 18 months for delivery.

A number of shops in Switzerland are still doing work for enemies of the Allies, but as this work is continually growing less they have attempted to build tools after the American model. This has been found expensive, as all coal and iron must come from Germany and the foundries charge from fr. 1.40 to 1.60 per kilo (12 to 16c. per pound) for castings.

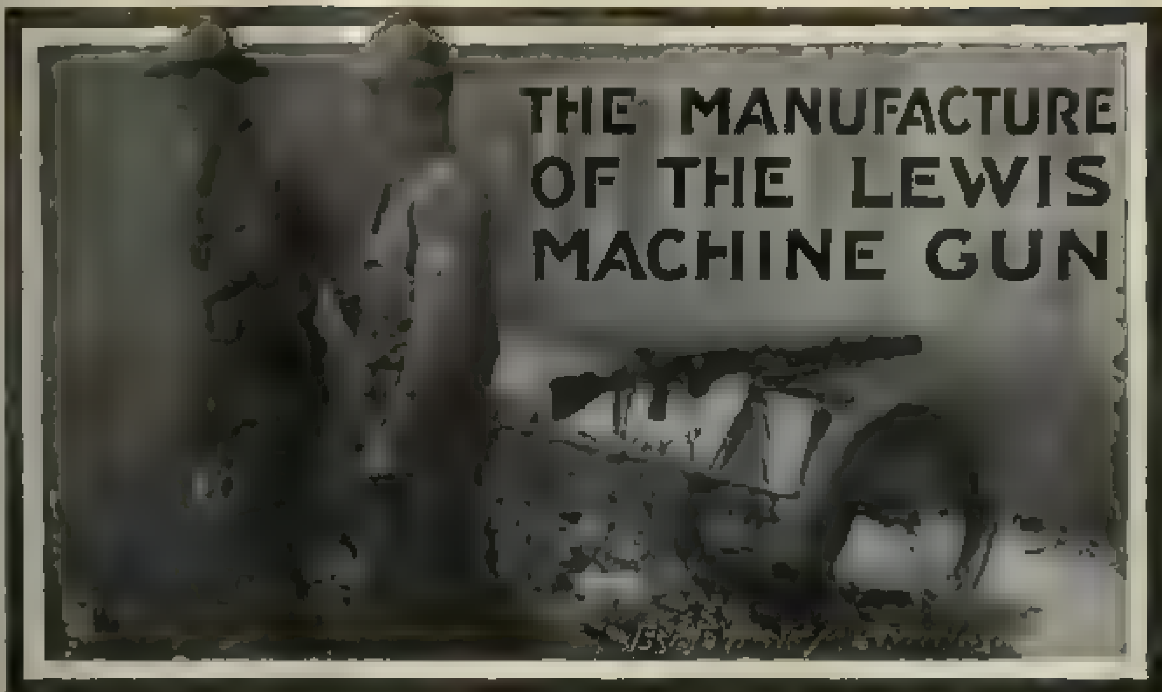
The Entente furnish to manufacturers who are building machines for the Allies hematite iron at fr. 38 per 100 kilos ($70 per ton) and Cleveland pig at $60 per ton.

Unsawable Prison Bars

By E. A. Dixie

I see by the papers that "the most desperate and resourceful criminal in the United States" has succeeded in sawing his way out of prison. This sort of thing does not happen very often but when it does a lot of us wonder why men of this stamp are not put behind case-carbonized bars. Then the "beautiful stenographer from Brooklyn" who carries 12 in. hacksaw blades under her errands into the cell of her Desperate Desmond will indeed be foiled. Carbonizing will cost about 1c. a pound, and it is reasonable to believe that all the prison bars in the prison could have been case-carbonized for less money than has already been spent in searching for this desperado.

Not only would the bars be made hacksaw proof by this process, but they would be harder to bend and consequently less easily removed from their seats in the masonry. There is still another side to this, that is, the humanitarian. Men in solitary confinement suffer from lack of exercise. Should a prisoner show such symptoms the guard could be empowered to slip him a hack saw frame and a dozen saws. His avidity for escape would bring the roses of perfect health to his pallid cheecks without hurting the bars in the least.



V. The Receiver IV

Devices for gaging important cuts are considered here, and methods of hollow milling and drilling are illustrated along with special apparatus for cutting out the receiver slot in a shaving process. The fixture for this is used in the shaping machine and embodies many worthy features.

REFERENCE has been made in the preceding chapter to the milling of the slot, or groove, along the bottom of the receiver for the reception of the guard or grip slide. This cut is originally made from the rear end of the receiver forging to a point near the base of the front lug for the gear case. The straight channel thus formed is afterward under-cut at the sides to form a guide like a T-slot for the grip slide. After the receiver has passed through various succeeding operations it is ready for operation No. 34, which consists in profiling the continuation of the grip slide cut to form the seat for the gear case.

This profiling cut is tested for accuracy of width and depth by means of the gage, Fig. 45, which also determines if the cut is correctly positioned on the center line of the receiver. The gaging fixture carries an offset bracket with head projecting over the center of the fixture, and through this head are bored two vertical [illegible]-in. holes in which are fitted a pair of sliding plugs *A* and *B* which carry at their lower ends two flat gages *C* and *L*. When the gages are seated properly at the bottom of the slot in the work, the tops of the [illegible]-in. plugs are exactly flush with the top face of the gage head. This forms a convenient means of gaging the slot depth.

A profiling fixture for the ejector-clearance slot in the left side of the platform top is shown in the illustration, Fig. 46. The form plate for the profiler-guide pin is seen quite close to the work at *A*, where the shape of the opening for the taper-guide pin is clearly indicated.

The gaging fixture for depth and position of this slot is illustrated by the line drawing, Fig. 47, and like other examples of gaging apparatus at this plant it has numerous features of interest.

The gaging fixture holds the receiver at the same angle as the profiling fixture, and in inspecting for depth of opening and lateral position in reference to the center line of the four plugs *G* and *H* are pushed straight downward into the profiled slot, the top of the gage plugs coming flush with the upper face of the gage head when the plugs seat properly in the slot. The four plugs are flatted at the lower ends to a thickness of [illegible] in., and when slipped down in service the two inner plugs *H* have their flatted portions parallel with the length of the slot, while the two outer plugs *G* rest with their gaging portions crosswise of the slot, so that they test the latter for width and position in reference to the receiver center line, plugs *H* giving the test for depth.

The length of the slot and its position endwise in the receiver is gaged by the two fingers *J* which are pivoted at an angle in the gage head so that the rounded inner ends may contact with the end walls of the slot and the outer ends come flush at *K* with the corresponding surfaces of the plates upon which they pivot.

Drilling-Machine Work

Following the profiling cut in the fixture in Fig. 46 there are several drilling-machine operations on the receiver, two of the most interesting being shown in Figs. 48 and 49. Duplicate jigs are used on the two multiple-spindle machines in these views, and these jigs are slid back and forth between the two machines.

The operations consist in hollow milling the round boss, or hub, at the front and top of the receiver, and

in drilling, reaming and chamfering the hole in this boss.

A drawing of the jig is reproduced in Fig. 50 and shows the method of locating and securing the receiver in position. It also shows the large bushing in the top plate for guiding the hollow mills and for receiving an auxiliary slip bushing for the smaller tools—the drill, reamer and chamfering counterbore.

Referring to Fig. 48 it will be seen that there are two hollow mills used in the process of machining the outside of the magazine boss, and one cutter for facing the top. These mills divide the cut, leaving a fairly light chip for the finishing cutter. The outside surfaces of the hollow mill bodies are ground to fit the guide bushing in the jig, and the shank for each mill carries a pair of large stop collars to limit the depth of operation.

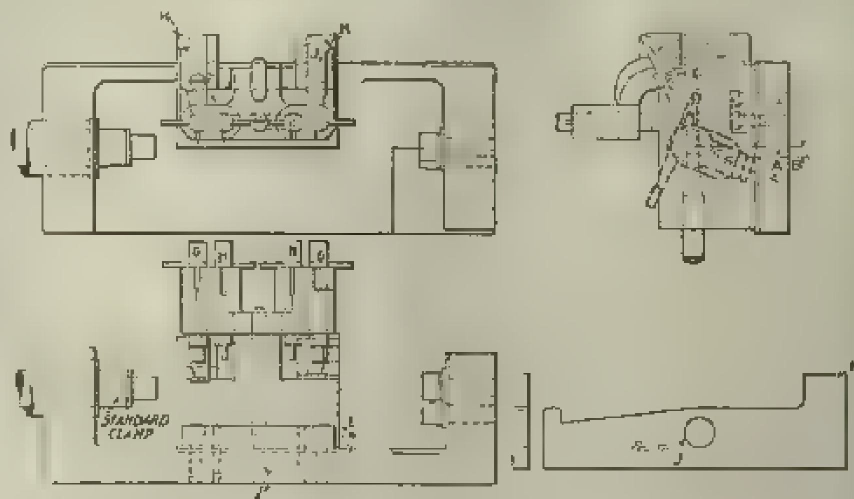


FIG. 47. DEPTH AND POSITION GAGE FOR EJECTOR-CLEARANCE CUT

The finish mill is of novel form, as will be seen upon inspection of the one near the front corner of the drilling-machine table.

The hollow mill has four teeth and is split at four points for adjustment in its sleeve, which has a tapered mouth to correspond with the conical portion at the cutting end of the mill. At the rear end of the mill there is a thread for adjusting the tool in its socket, the adjustment being effected by an internal wrench which is slipped up inside of the mill. The same wrench operates a locking nut from the inside.

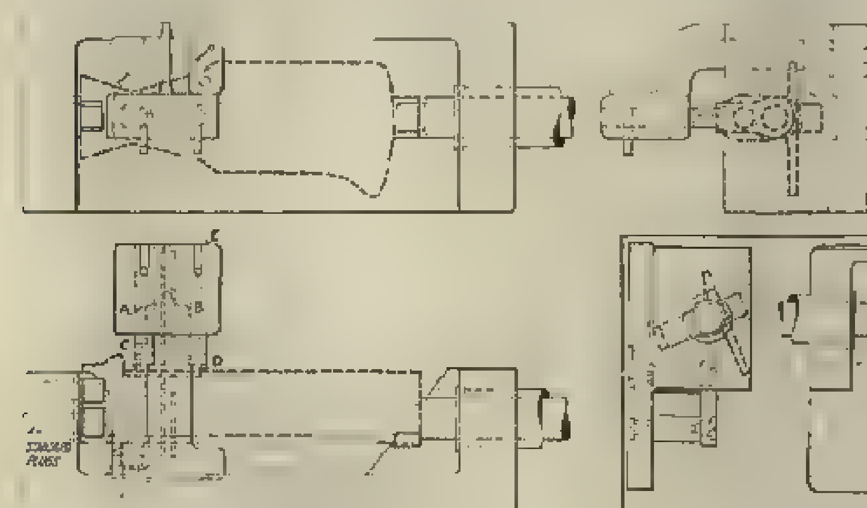


FIG. 48. GAGE FOR PROFILED SLOT

In making the hollow mill, the blank is bored slightly larger than finish size, then closed a trifle and ground out near its cutting edges, leaving a little clearance behind the lips. The method of adjusting in the socket, or holder, by an inside wrench is a convenient one, and the interior locking nut is a positive safeguard against changing of the size through accidental slipping of the mill.

In the six-spindle machine, Fig. 49, there are two sets of drills, reamers and chamfering counterbores, the tools at one side of the machine are for roughing, the other set for finishing.

Gages are provided for testing the size of hole, the depth of chamfer and the depth of the hole bottom. The depth gage for the hole is a flush-pin device with a rectangular head which is adapted to rest upon the upper face of the fixed bushing in the jig. The method of applying this depth gage is shown in Fig. 49. A similar class of gaging tools is provided for the operations on the boss in Fig. 48, where the gage set is shown in the wood case at the front of the jig holding the receiver

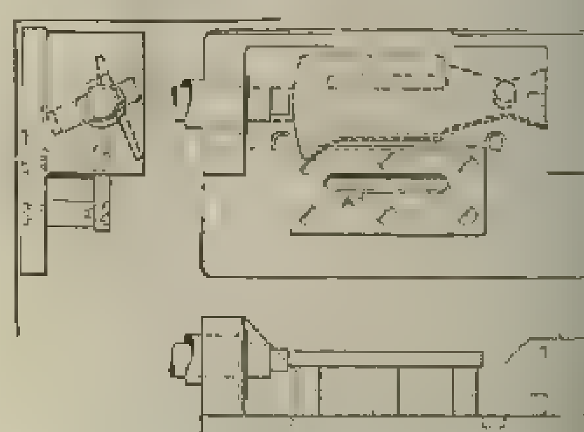


FIG. 46. PROFILING FIXTURE FOR EJECTOR-CLEARANCE CUT

Passing along now over a number of milling and profiling operations we come to a very interesting method for shaving out the metal between the two long holes through the receiver to form the bolt locking

lug clearance slot. This is done by means of a special fixture used on the shaping machine, as shown in Fig. 51. In this view two receivers will be noticed in the pan at the front of the fixture, one before the shaping

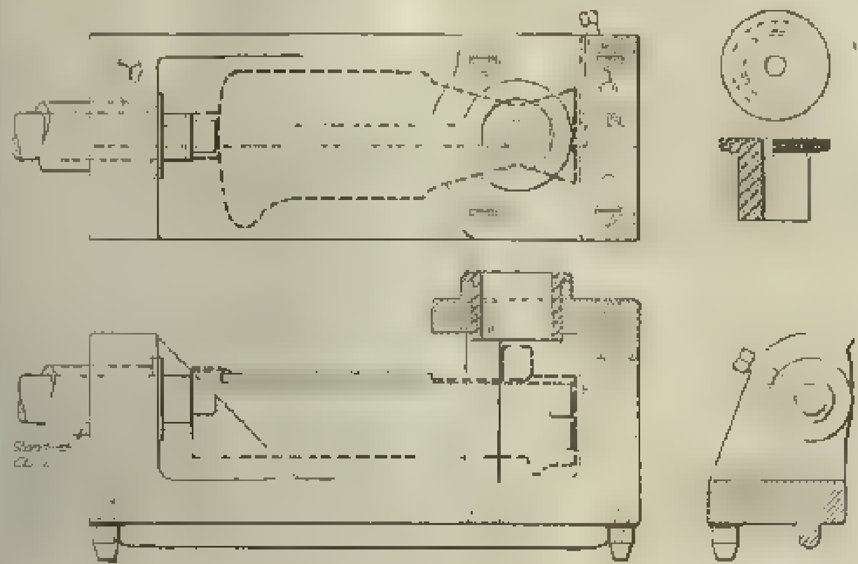


FIG. 50. DRILL JIG FOR MAGAZINE BOSS

operation has been done, the other showing the end of the completed slot formed by cutting out the metal between the large hole and the piston bore in the receiver.

This apparatus is used also for cutting out certain other internal clearance slots in the receiver for the bolt lugs; but as this operation is identical for the different cuts the following description will be confined

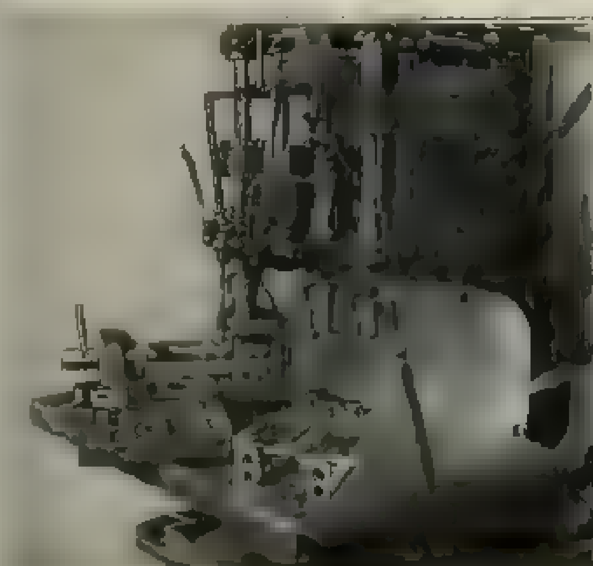


FIG. 48. HOLLOW MILLING THE MAGAZINE BOSS ON THE RECEIVER

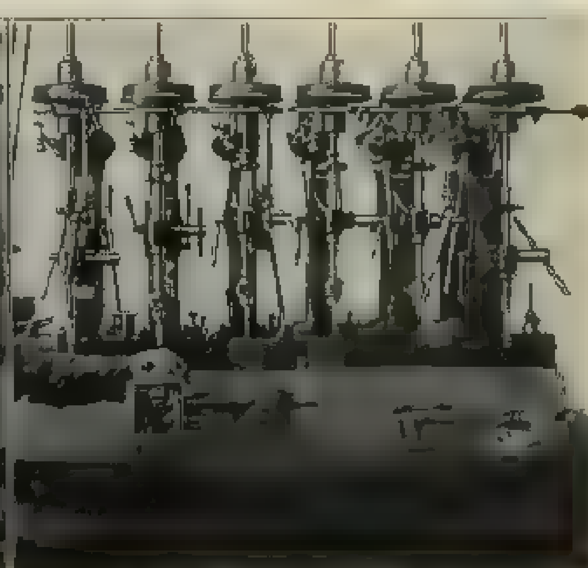


FIG. 49. DRILLING AND REAMING MAGAZINE BOSS ON THE RECEIVER

principally to the application in machining the wide slot for the locking-lug clearance referred to in the preceding paragraph.

An assembly drawing of the shaping or slotting fixture is shown in Fig. 52. The cutting tool and its bar are not in position in this engraving. In Fig. 51 this cutter bar will be seen extending through the work and connected with the special head on the shaping-machine ram and with the feed mechanism at the outer end of the fixture.

Referring to Fig. 52 it will be seen that the special ram head *A* carries an operating shaft *B* which travels back and forth in a guide bushing in the end of the fixture and which reciprocates the cutter bar for shaping out the metal in the receiver. At the outer end of the fixture is located the head *C* for guiding the outer end of the cutter bar and feeding the shaping tool to the cut.

The end view shows the pawl arrangement for rotating screw *I*, by means of the ratchet teeth on the large head or disk at *J*. Pawl *K* is carried by a vertical plunger which has a beveled lower end acted upon by the corresponding end of feed slide *L*. This feed member is [illegible] in. square and extends through the whole length of the slot planed in the bottom of the fixture. When the shaping-machine ram approaches the end of its forward stroke a stop screw *M* strikes the rear end of feed slide *L*, and moving that slide forward against the action of compression spring *N* causes the bevel end plunger *O* to be lifted and the pawl to act upon the ratchet head screw *I*. The travel of feed slide *L* is varied to give any desired amount of feed to the cutting tool by the adjustment of the stop screw at *M*

The ratchet head *J* of the hollow feed screw *I* carries an adjustable stop plate *P* which may be set to throw out the pawl *K* at any point and thus disengage the feed for the cutting tool.

The receiver to be slotted is supported on the long arbor *Q*, which fits the small bore in the receiver and which is flatted off the entire length of its top to provide clearance for the shaping tool when it has cut downward through the wall of metal between the two holes. The feed head *C* at the end of the fixture is pivoted at *R* and locked in place by a T-head screw at *S*, which given a quarter turn allows head *C* to be swung back out of the way to facilitate the removal and replacing of work in the fixture.

Special Drawhead

The special draw head, which reciprocates the cutter bar, is drilled out and tapped for oil-pipe connections and the oil channels leads to a chamber at the center through which lubricant is forced under pressure to and through the hollow cutter bar to the working edge of the tool. This head carries an adjustable member which has a hexagonal opening fitting the corresponding shoulder on the operating bar. By turning the opposing screws the bar may be rotated slightly to adjust the cutter bar, thus bringing the cutting tool into truly central position for starting the slot.

The cutter bar *D*, Fig. 53, is in the form of a hardened steel tube. The hollow cutter bar is slotted near the middle of the length to form an opening for the cutter *E* which in working position is confined endwise between the spring plug *V* at the rear and the sloping surfaces of the wedge *F* and the bevel end of the slot at the front.

There is a V-notch in the front end of the plug to form a seat for the taper and rounded rear end of the cutting tool *E*, and on the outside of the plug there are four narrow grooves for oil passages.

The cutter is confined sidewise between guiding surfaces formed by two segmental strips *Z* which are secured on opposite inner sides of the tube by sweating in place.

The operating wedge *F* is ground cylindrically to fit the bore and flatted on its sides to enter between the cutter-guide plates. The series of notches across the top of the wedge come opposite another slotted

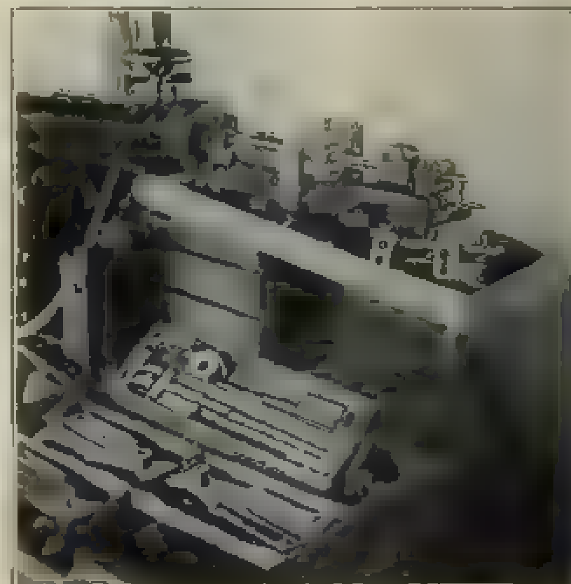


FIG. 51. SHAVING FIXTURE FOR CLEARANCE SLOTS FOR [illegible]

opening in the tube and form a means by which the wedge may be withdrawn after the work is completed so that the cutter may swing up into the tube.

The wedge, like the operating screw at its rear, is made of tool steel. The screw referred to is $\frac{5}{8}$-in. in diameter having a quadruple V-thread, 16 pitch, 1-in. lead, right-hand. This gives a very steep helix on this small diameter screw. A tension member to assure snug adjustment to the thread in the nut is provided in the form of the copper strip *G'* which is retained in a groove in the screw by two small fillister-

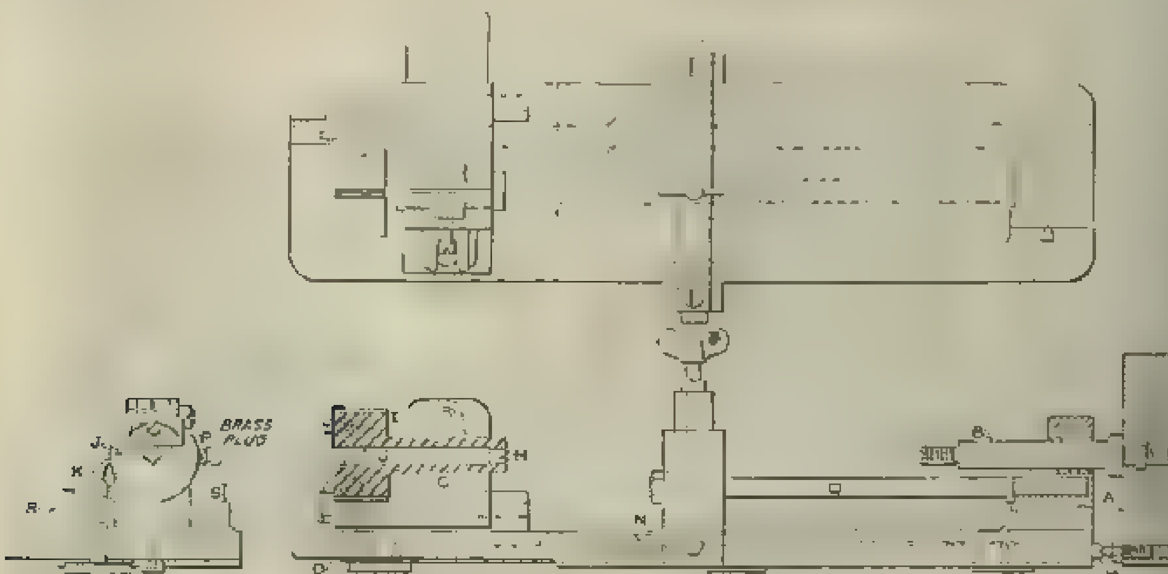


FIG. 5[illegible] THE SHAVING FIXTURE ASSEMBLED

head screws. The copper strip is threaded in position in the screw, and when in place in the nut it is forced outward by the two short springs in the body of the screw G, this adjustment being provided for by the clearance under the heads of the retaining screws which are used.

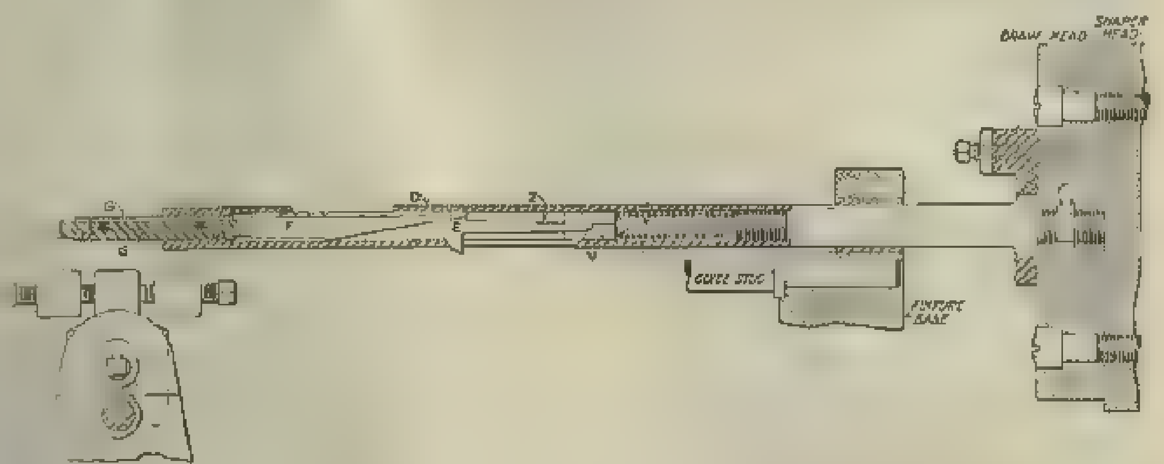


FIG. 53. CUTTER BAR AND TOOL DETAILS

Industrial Conditions Prevailing in England

BY DON J O'BYONE

Ever conservative and always patriotic the British machine-tool manufacturer has entirely lost sight of his individual interest in the worthy effort of prosecuting the war. He has sacrificed his art of invention and all theories of production to the dominant task of the moment. He is taking no chances with Mars. The tool or the machine that was not absolutely necessary to war efficiency has been lost sight of and the consequence is that in these days a great part of the everyday Britisher's life is lived in a fashion that suggests a reversion to the primitive. The consequence is that five of the largest machine-tool manufacturers in the United Kingdom have gone into liquidation during the past year—one voluntarily, the affairs of the other four being wound up by the Board of Trade.

The Machine Tool Association, Limited, the great organization of manufacturers, has joined in the appeal for the Industrial Reconstruction Council. The object is to conserve the industrial health of the nation that now exists and to revitalize industries. Of course such a scheme of reconstruction deals with varying elements, such as the bringing together of labor and capital, the creation of demand, etc., but the machine-tool men have injected a positive demand for government subsidy to enable them to keep up their battle in the economic arena. At their meeting to discuss ways and means, Feb. 21 last, J. Judson of the Judson-Jackson Co., of London and Birmingham, one of the largest firms in the big-tool trade, complained that excess profits were based wrongfully on the prewar standard of profit. He referred to the enhanced price of American machine tools and said he doubted if a single member of the association was receiving half the sum for British-made goods. He looked forward to German competition after the war and said that the practical isolation of the Central Powers during the past three years had compelled them to manufacture their own tools and thus stimulate their genius as well as their capacity for production. Speaking of all postwar competitors as a class Mr. Judson summarized the government's duty to the machine-tool men and the manufacturers' duty to themselves in the following words:

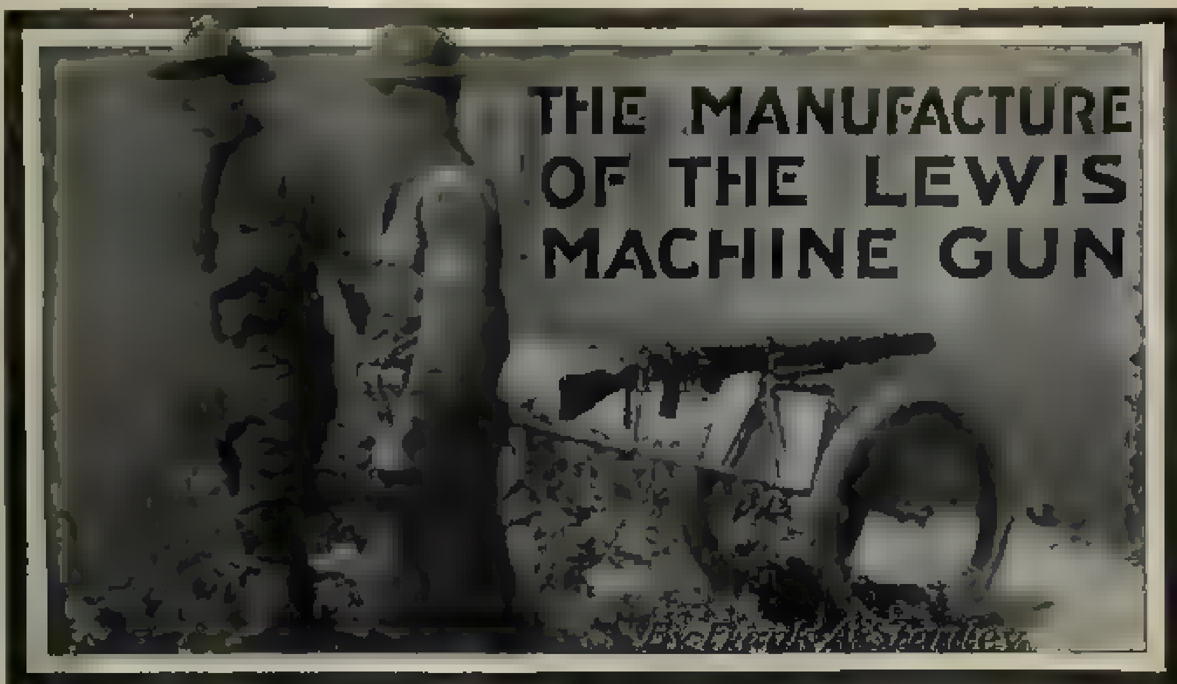
"If they [competitors] travel we must travel; if they advertise largely so must we; if they plane a given-sized lathe bed in ten hours so must we; if they machine a certain-sized pulley in two hours so must we; if they adopt more up-to-date machinery so must we. What is the remedy for the state of affairs with which we find ourselves surrounded? At present the nation is spending about £7,000,000 ($35,000,000) a day on destructive purposes. Let it spend an equivalent amount for constructive purposes. By allotting a few hours' war cost to the machine-tool people the government would be restoring a most important industry to an absolutely sound basis."

The great length to which Britishers have gone to efface their personal desires and to concentrate on war efficiency is an interesting chapter. Nothing is made except the absolute necessities of life for the stay-at-homes. The only pleasures the average Londoner allows himself are his ale and the theater.

The reversal to the primitive in manners of living has had a serious effect on all manufacturers whose plants could not be adapted to war needs, and the recital of simple living to which the people have settled down might sound ludicrous in this enlightened age were they not the annals of patriotic self-sacrifice. Everything advertised in the newspapers and magazines must have a war use or the advertisement is frowned upon. The inventor with ideas other than tried and proved ones finds no market for them.

Shoe machinery should be in great demand, but the British manufacturer literally "sticks to his last." This is no time to make a change in his methods of production and he will not. Again, the people are encouraged to repair their own boots and shoes, and the writer has seen women who were more at home in the refinement of their own homes than in the environs of cobbler's shops proclaim their genius as shoe menders.

THE MANUFACTURE OF THE LEWIS MACHINE GUN



By Frank A. Stanley

VI. The Receiver—V

The illustrations presented show unusual profiling cuts, spline-milling tools for an angular slot and special grinding and reaming appliances. The grinding apparatus finishes the end of the receiver to correspond to a height gage under which the work is tested in vertical position, and the reaming tools accomplish the difficult task of forming the tapered sloping wings for the cartridge guide in the top of the receiver

FOLLOWING the performance of the operations already illustrated there are a considerable number of additional profiling cuts to be made at various points on the receiver, and several of those are illustrated herewith.

The first operation to be shown in the present views is represented by Fig. 54 and illustrates the process of profiling the ejection opening which is cut through the body of the receiver and into the main hole from the right-hand side of the forging. It is accomplished in the fixture for holding the receiver swung over at the necessary angle for the profiling cut, this fixture having at the right two form plates for the guide pins. The lower plate of the two contains the guide slot for the profiling of the right-hand side of the ejection opening, which is seen under operation in the illustration. The opposite side of the slot is profiled out with the guide pin working in the slot of the upper plate, which is here represented swung out of position at the back of the pin. This supplementary guide plate is pivoted on a stud near the rear end of the lower former, and when swung around into operative position it is fixed in correct location for controlling the work movement by means of the knurled-head plug, which is slipped through the aligning holes at the front end of both form plates.

Two receivers are seen on the table in front of the fixture, the one at the right with the ejection opening roughed out with an ordinary milling cutter, while the other one has its opening profiled to finished dimensions.

The fixture which holds the receiver for this operation has an index plate at the rear, with notched openings for the locking lever shown at the left, so that the receiver may be adjusted into two different positions about its axis for the profiling of the opposite sides of the slot.

Another profiling operation is illustrated by Fig. 55, which shows the method of milling out the inside of the platform ledge and the forming of the small lugs for the reception of the feed cover. In this fixture the front half of the platform surface is faced practically all over, the two receivers in the foreground showing clearly the appearance of the platform before and after profiling.

In connection with the finishing of broad surfaces, such as the top of the receiver shown, an unusual type of finishing cutter is sometimes applied, which has in place of the conventional end-mill teeth a number of V-grooves cut parallel straight across the end of the mill, forming a series of straight file-shaped teeth. This type of cutter acts as a rotary file for smoothing up the surface after the regular end mill has been used and is intended to remove only a very small amount of metal.

The gaging fixture shown to the right in Fig. 55 is used in connection with the inspection of receivers after the platforms have been profiled to form the holding lugs along the inner surface of the ledge, as seen to the left in this view. The same fixture also gages the height of the flat surface profiled across the platform. The interesting feature of the gage is the provision for testing the positions of the small interior lugs referred

to and the adjoining surfaces of the wall or ledge along which these lugs are formed.

The gage plugs for checking these locations are milled off across their lower ends, forming a flat surface whose thin edges serve as the gage proper. The tops of the plugs are provided with small knurled extensions by means of which the gage members are rotated with the fingers to bring the narrow lower edges into contact with the work at the points that require gaging. The plugs thus constitute rotary-feeler gages which, when turned around in their sockets, must come into light contact with the surfaces under inspection.

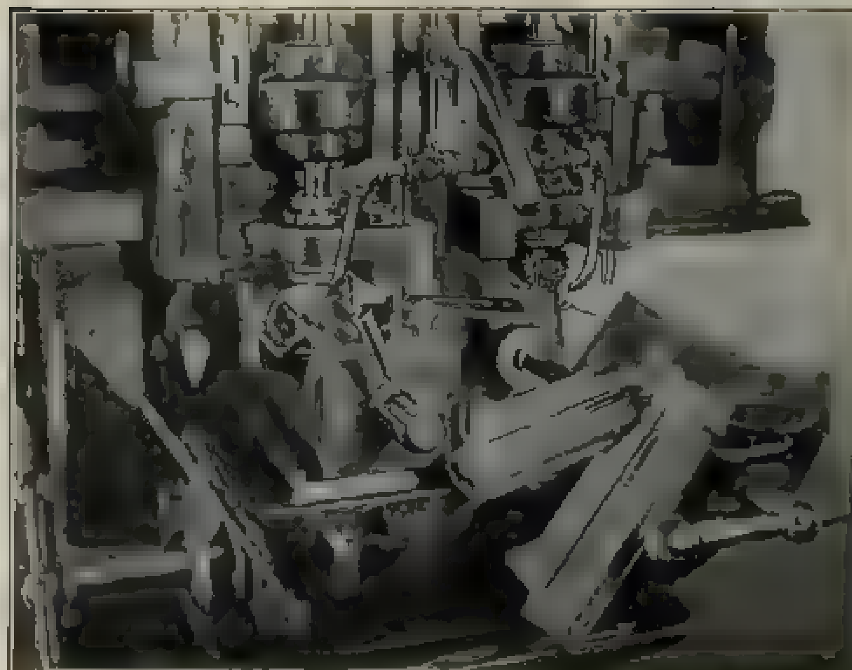


FIG. 54. PROFILING EJECTOR OPENING IN THE RECEIVER

While considering the type of tool in which the gaging members are rotated by the fingers, it will be of interest to show one more example embodying unusual features. In Fig. 56 a fixture is illustrated for gaging the position and width of the charging-handle clearance slot profiled in the side of the receiver in an earlier operation. The upper ends of the pins are flush with the top surfaces of the heads which carry them; that is, the upper ends must be flush when the bottom projections are swung into the slot in the work. In this way the slot width and its position in the receiver are accurately checked.

In the profiling operations so far illustrated the re-

FIG. 55. [illegible] TOP AND INNER [illegible]

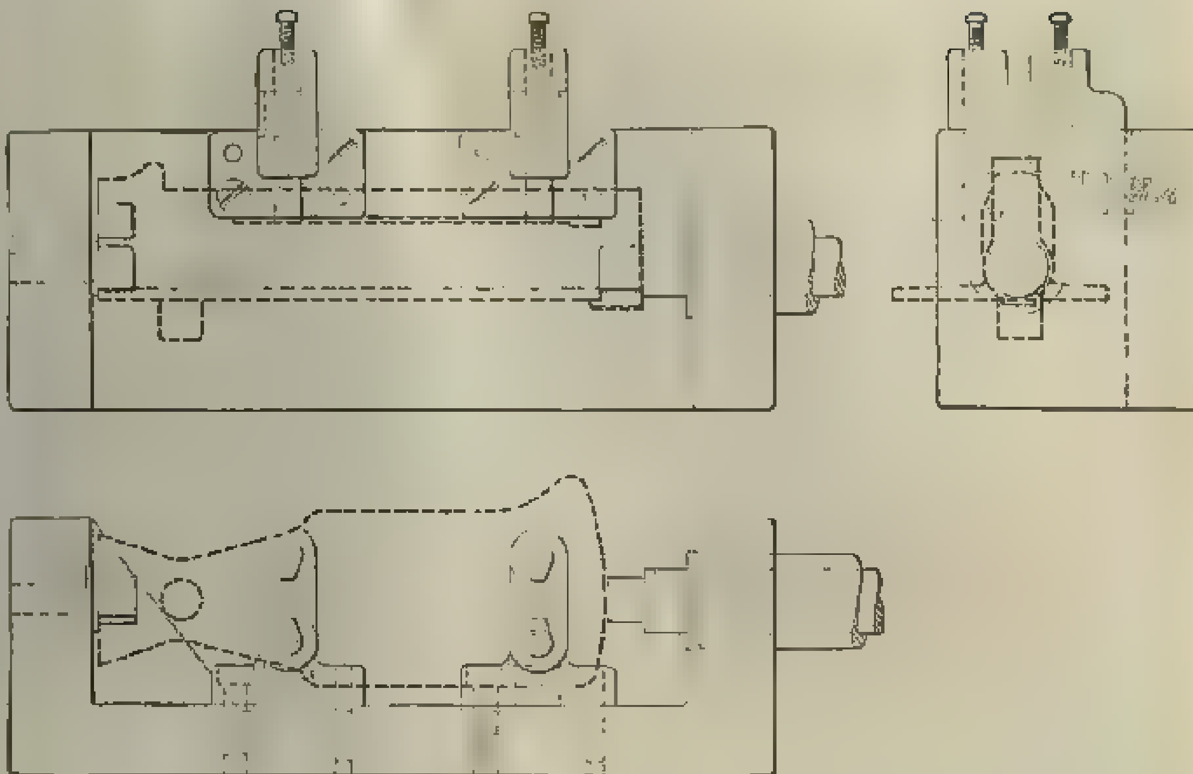


FIG. 56. GAGE FOR [illegible] HANDLE CLEARANCE SLOT

ceiver has been held in horizontal fixtures on the table of the machine. There are, however, a number of profiling cuts that have to be made with the receiver supported vertically, and one operation of this character is illustrated in Fig. 57, which shows the work set up for the recutting of the extractor, clearance cut on the inside and at the side of bolt bore in the receiver.

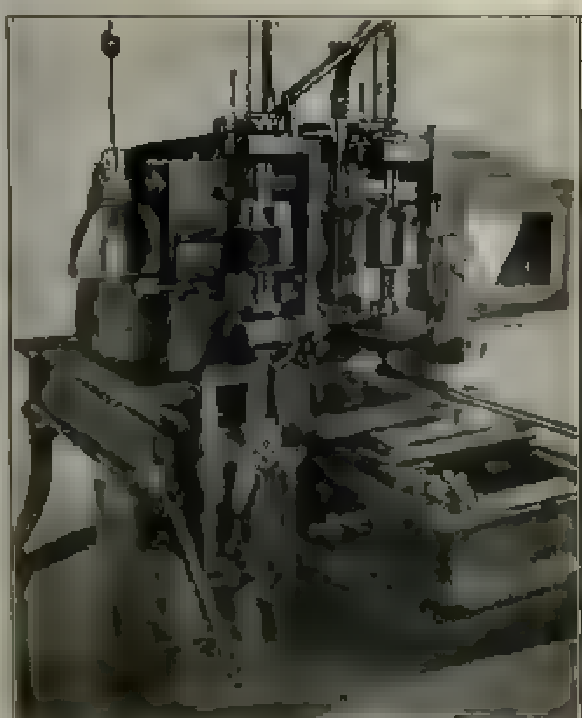


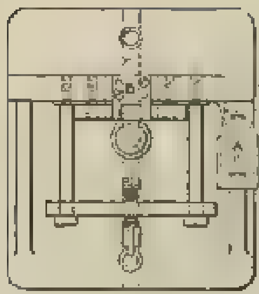
FIG. 57. RECUTTING EXTRACTOR CLEARANCE

The clearance cut is made with a profiling tool resembling a taper reamer, which is sunk into the metal at the side of the bore to produce a clearance pocket of the desired form and depth. This tool is clearly seen in the illustration, where the carrying fixture for the receiver is shown at the lower end of its guide, so that the top of the receiver stands clear of the cutting tool. The work-holding fixture is adjusted vertically in the guide at the side of the fixture base by means of the lever at the left-hand side, this lever having a pivot connection at the rear and a slot in the middle which receives an offset stud in the sliding fixture for the purpose of elevating the latter to the proper height for the forming of the clearance cut. When the slide with the receiver has been lifted into operative position it is locked for the taking of the cut by means of a plug which is slipped back into a fixed bushing in the rear of the vertical guide.

Securing the Fixture

The base for the fixture body, which is planed at right angles to the vertical guide referred to is secured to the profiling-machine table in the usual manner. The top of this baseplate is planed off and shouldered, as indicated, for the attachment of the form plate, which in conjunction with the guide pin in the spindle head controls the movement of the profiling cutter inside the bore of the receiver.

Another vertical fixture which holds the work upright on the profiler is shown in Fig. 58. This is used in profiling the rounded shoulder shape at the rear end of



the receiver, the shape of this contour being indicated by the outline of the form plate *A*. The receiver is located at the bottom on the shouldered plug which fits the counterbore at the front end of the receiver, while the upper end of the work is positioned by the lug at the back of the receiver platform which enters the opening in plate *B*. The receiver is held in this upper locating plate by the thumbscrew in slotted strap *C*.

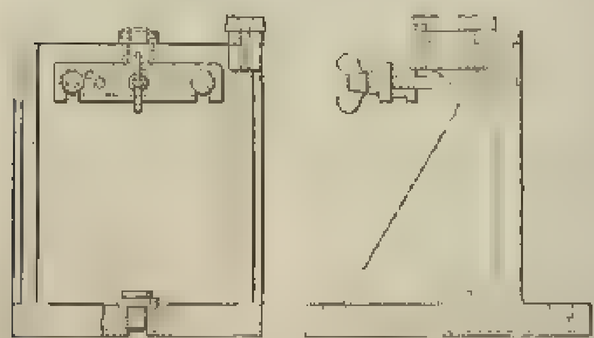


FIG. 58. FIXTURE FOR PROFILING END OF RECEIVER

An awkward slotting operation which is accomplished on a spline-milling machine is represented in Fig. 59, which shows all details of the fixtures for holding the work on the table of the machine. This operation is the spline-milling of the ejector-clearance front slot. As will be seen from the plan and end views, which show the receiver and slot distinctly, the latter is at an angle to the bore of the receiver and also to the top surface of the work. The small slot must be cut by passing the shank of the spline-milling cutter through the ejection opening already profiled in the opposite side of the receiver wall.

The slot to be cut is seen at *D*, Fig. 59, and the spline-milling cutter at *E*. The holding fixture consists of two heads *F* and *G*, the former carrying locating plugs *H* and *I* and the latter the shouldered clamp plug *J*, which is mounted and operated in the same manner as in the case of numerous other fixtures already illustrated.

Milling, Profiling, Polishing and Grinding Operations

Following the above operations there are a number of milling, profiling and polishing operations to be done before the receiver is ready for the grinding of the face end. This operation, No. 104, is accomplished in the manner illustrated in Fig. 60. The receiver is here mounted on an arbor in the engine lathe, and a special outer support is fitted to the inner shears of the lathe. The grinding attachment is secured to an adjustable head on the carriage cross-slide, and the wheel spindle is swung crosswise to the centers to bring the edge of the wheel into contact with the work.

The grinding operation is carried along in conjunction with a gaging process for checking the over-all length of the receiver. The gaging device is shown at the right of the grinding fixture. It is similar in form

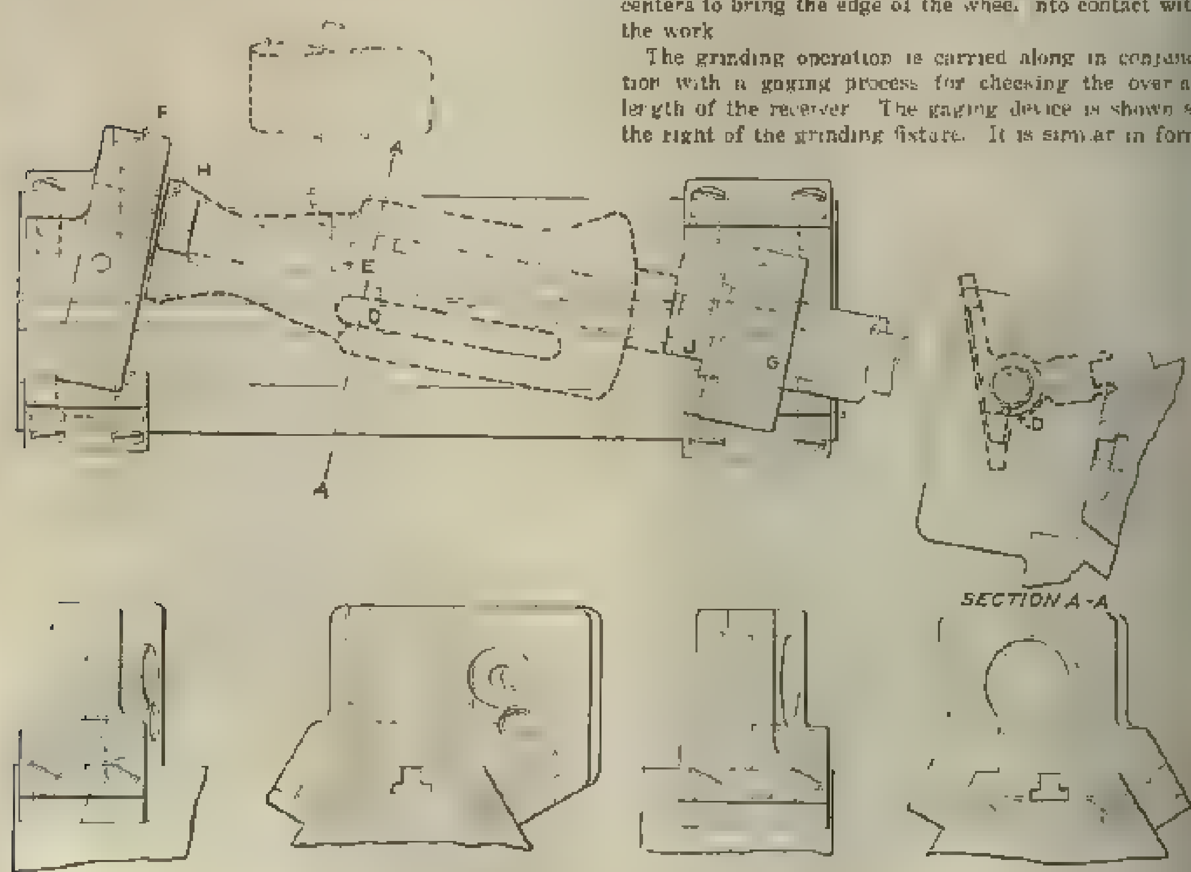


FIG. 59. EJECTOR CLEARANCE SLOT-MILLING FIXTURE

to the one used in connection with the original end-facing operation on the turret lathe. Its base carries an upright plug fitting the receiver bore and ground off at the

FIG. 60. GRINDING THE END OF THE RECEIVER

top to form a height gage for the length of the work, the top of the plug being used as a setting point for the dial indicator, which is carried on an arm mounted at the upper end of the other post located on the fixture base.

A receiver undergoing end-grinding operations may be placed over its plug on the gage and the dial indicator then applied to the top of the plug and the end of the work to determine how many thousandths must be ground off the receiver face. When the receiver is placed in the lathe and the grinding wheel brought into contact with the end surface a micrometer stop gage at the left side of the carriage may be set to limit the grinding operation in accordance with the readings previously noted on the dial indicator of the upright gage.

After this operation both holes in the receiver are again lapped and a number of other operations, mostly hand, are performed.

Machine Operations Performed on the Cartridge Guide Wings

Guide wings are placed at the sides of the slot on the top of the receiver, through which the cartridges from the magazine are guided down into the gun. The wings slope downward at an angle toward the front of receiver, and the opening between them tapers slightly with the greater width of opening toward the front. The narrow edges along these wings are machined to the required form and degree of taper in the drilling-machine fixture shown in Fig. 61. The fixture is mounted on a sloping base which tilts the fixture backward to the necessary angle for the machining of the wings for the cartridge guide.

The tool used in making the cut is in the form of a taper reamer with a long shank, which fits in the guide bushings as shown. The lower end of the reamer has a small pilot which enters another bushing near the lower end of the fixture. The cutting part of the reamer thus supported above and below is fed downward with the drilling-machine spindle into the cut. Means of adjusting the bushing-carrying head are indicated in the illustration.

Fig. 62 illustrates a fixture for hand reaming these cartridge-guide wings and shows more clearly the application of the finishing tool. The large end of the reamer is attached to the long shank by a threaded tip on the latter, which fits a tapped hole in the reamer body, and has a threaded portion on this diameter for stop and lock nuts which limit the depth to which the tool is to be operated. The tool is operated by the knurled disk attached to the outer end of the shank, and when run down to depth the stop collar prevents further end movement by coming in contact with the bent arm of the steel stop bracket *B* which is secured by screws to the back edge of the reamer guide illustrated at *C*. The drawing of the fixture, Fig. 62, illustrates fully the method of holding the receiver in position, and the front elevation shows the manner in which the tapered

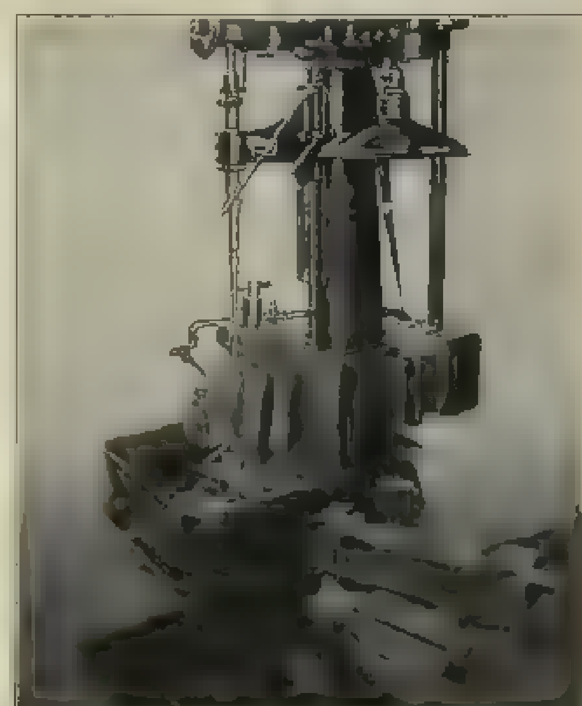


FIG. 61. REAMING CARTRIDGE-GUIDE WINGS

reamer passes down into contact with the edges of the cartridge-guide wings when the tool is fed along with the hand knob. The shape of the opening between these wings and the clearance cut in front of them may be seen in the plan view of the fixture, where the outline of

the top of the receiver is clearly represented by the dotted line.

The accuracy of the cartridge guide wings finished in the taper-reaming process is tested by the application of the flush pins in the gage shown to the right

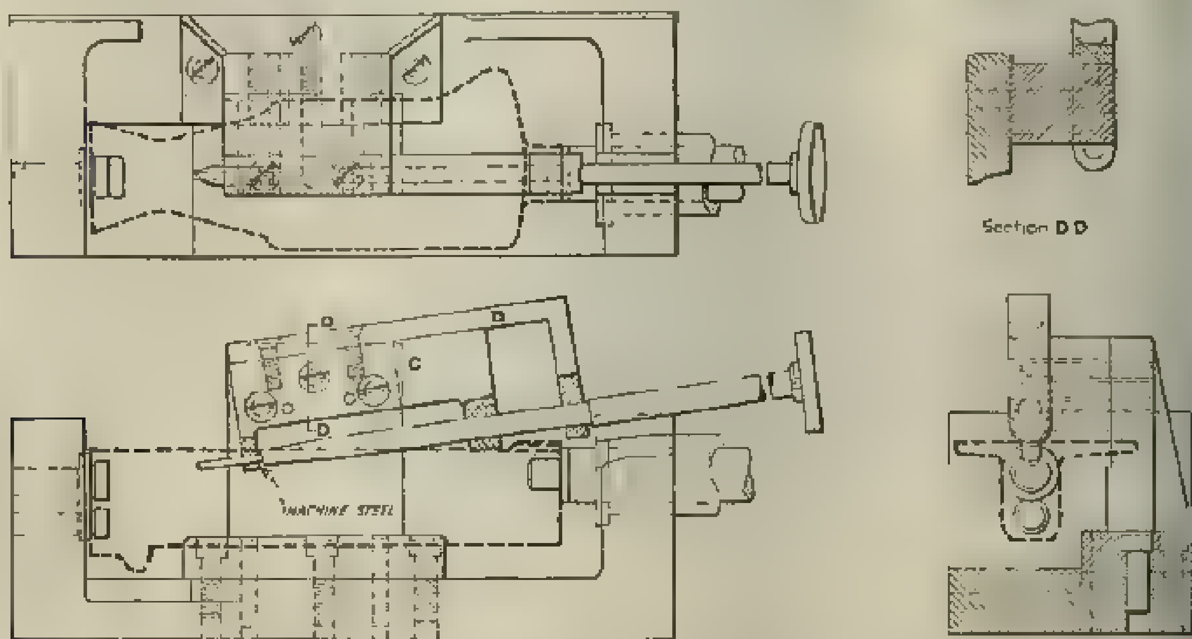


FIG. 62. HAND-REAMING FIXTURE FOR CARTRIDGE GUIDE WINGS

in Fig. 61, the lower ends of these pins having suitable outlines and dimensions for testing both the position and depth at each end of the wings.

A Nation-Wide Americanization Plan

The Americanization conference recently held in the Interior Department at the call of Secretary Lane adopted the following resolutions:

1. The adoption of the policy that the federal Government should coöperate with state and, through the states, with the local communities in carrying on an extensive, intensive and immediate program of Americanization through education, especially for non English-speaking foreign-born adults.

2. That the industries employing large numbers of non-English-speaking foreign-born persons should coöperate with local communities and with the state and federal governments in carrying out this proposition.

3. That adequate appropriations should be provided by Congress to be expended through appropriate governmental agencies for the foregoing purpose.

4. That in all schools where elementary subjects are taught they should be taught in the English language only

This conference was attended by 18 state governors, representatives of the State Councils of Defense, and representatives of industrial concerns. The following committee was appointed to present a program to Congress: Governor Stewart of Montana, Governor Manning of South Carolina, Governor Milliken of Maine, Levy Mayer of Chicago, Harold T. Clark of Cleveland, Arthur T. Somers of New York City, Hale Holden of Chicago, Samuel Gompers of Washington and Robert Newton Lynch of San Francisco.

This is the beginning of what can and should become a movement of great importance. But it must not be forgotten such a vital question cannot be successfully handled perfunctorily. It is not a matter of passing resolutions and then letting things go on as before.

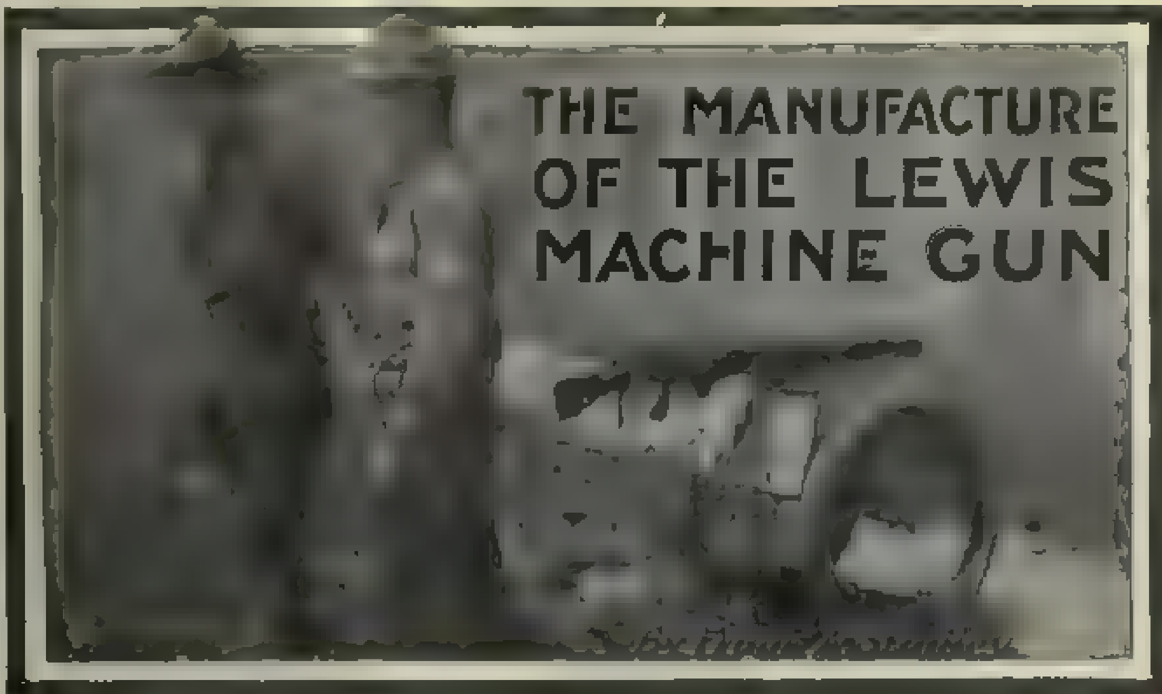
There is great need for a real Americanization movement all over the land, but it is a bigger problem than is realized. It is a human problem and must be handled in a humanly way by men and women whose personality is peculiarly fitted for this work. It must not be delegated to those who lack sympathy with those among whom they will labor and who hold race prejudices of any kind.

Americanization is more than the teaching of English and learning the Constitution. It is the inculcation of American ideals and ideas. And this can only be done by showing the foreigner that they are real, not sham.

We must all help if Americanization is to become real. In our daily contact with the foreign born we must show that we mean what we say; that this is the land of the free and the brave; the haven for the oppressed—not a place where oppression merely takes a different form. The foreign born must have a fair chance, must not be exploited by employer or fellow worker He must be treated as a human being without patronage or hypocrisy

The Americanization of our foreign born is a real problem and one which all of us must join in and settle It will not be helped by personal abuse of Germans, by the burning of German books or by forbidding the teaching of the German language. It cannot be entirely delegated to even the most competent teachers

There are a number of books on this subject and all interested should communicate with the National Americanization Committee, Engineering Building New York



VII. The Receiver—VI

This closing article on the receiver will be confined principally to certain important operations that take place as the work approaches completion. The illustrations show the milling of the barrel thread in the front end of the receiver, the qualifying of the front end after threading, the grinding of the magazine hub to gage, and the grinding of the lock-up shoulder in the bore, which is the last machine operation performed on the receiver, the piece being ready then for assembling.

THE thread-milling operation in the front end of the receiver is accomplished with an attachment in the engine lathe, which is illustrated in Fig. 63, where the work will be seen held in a special fixture which is mounted upon the nose of the lathe spindle and supported at its outer end in a steadyrest, the jaws of which are adjusted to a cylindrical surface finished at the outer end of the fixture body.

The receiver in this operation is carried at its inner end upon a split plug or short mandrel fitted in the back of the lathe fixture, and adjusted to fit tight in the receiver bore by means of a tapered plug drawn back into the carrying mandrel by a closing rod and handwheel operated at the rear end of the spindle. The outer end of the receiver in which the thread is to be cut is securely clamped in the front end of the fixture and is then tested in the mouth of the hole for running true by means of the dial indicator shown mounted upon the upright on the baseplate to the left of the carriage. This indicator is constructed with a floating contact arm, the rear end of which operates under the spindle of the dial gage, so that any oscillatory movement of the front end of the arm is transmitted to the gage pointer where the fluctuations may be read on the dial. By application of the indicator to the end of the receiver counterbore the work is assured of running true before threading operations are started.

The milling-cutter spindle is mounted in an adjustable head on an upright fitted at the bottom for lateral adjustment on the cross-slide guide on the carriage.

The lathe-spindle drive is modified to give the necessary slow rate of rotation to the receiver during the thread-milling process. It will be understood that the milling apparatus is adjusted at the outset so that the cutting teeth will start the thread at the exact predetermined point in the rotation of the receiver. With similar procedure in milling the thread on the barrel, the qualifying operations for assuring correct results in assembling these parts will be greatly facilitated.

This naturally necessitates the application of some device for locating all receivers in the rotating fixture in precisely the same angular position about the axis of the holding plug or mandrel at the rear end. The means of establishing this relationship between the work and the rotary-fixture barrel is found in the hardened plug inserted in the plate which is definitely located across the front end of fixture and work, this plug entering the small hole or piston bore in the receiver.

In Fig. 68 a threaded receiver is shown on the lathe-carriage wings with half the rear end cut away to show the character of the threaded and counterbored portions that form the chamber for the reception of the barrel. The gages for testing the threads are seen on the bench immediately in front of the work.

Of the three gages shown in the group the one to the left is for testing the thread alone as to accuracy.

The gage at the right is a qualifying tool and is applied to the work to determine if the thread is located correctly in respect to the end of the receiver, so that when the gun is later assembled the barrel will screw up snugly to the abutting shoulders, with its locating lug in correct position, that is, on the top and central with the center line of the receiver.

The application of a qualifying gage in the bench operation is shown by Fig. 64. Each receiver is here touched with scraper and file, removing the least possible amount of metal until the edge of the gage comes almost into coincidence with the receiver edge. It requires very little touching of the work at this point to bring the gage up to the desired position, and it is of interest to note here that the final qualifying operation is not performed until after the receiver has been passed through the browning process, as the very thin coating formed or deposited upon the work has to be dealt with in the final test with the qualifying gage. The browning and finish qualifying, therefore, come almost at the end of the series of operations on the receiver, the only ones that follow after (aside, of course, from inspecting) being the grinding of the internal lock-up shoulder and the assembling in the gun.

It has been pointed out that as the receiver approaches completion there are various bench operations in the line of shaving and filing of certain surfaces all worked to gages and taking care of various points where machine finishing to gage would not be feasible. These hand processes all told are, however, few in number—remarkably so, in fact, considering the total number of operations on the complete schedule. These qualifying operations just referred to are possibly the most important and most interesting of the series.

FIG. 64. USING THE GAGE FOR QUALIFYING

FIG. 63. MILLING THE THREAD FOR THE BARREL

There are two more machining illustrations which it is desirable to present in this article, both having to do with grinding. Fig. 65 illustrates the method of finishing the magazine hub or boss at the end of the receiver with the aid of a grinding attachment. The machine employed is a flat turret lathe with a big open faceplate for mounting the work-holding fixture and a pair of slides for carrying the grinding attachment on the turret.

The character of the work fixture on the faceplate is plainly illustrated, and the method of operating the grinding wheel over the magazine boss will be apparent to the observer. The fixture for gaging the boss after the receiver has been removed from the machine is seen to the right of the turret. Ring gages are, of course, used for testing the boss before the receiver is taken out of its grinding fixture. The gaging device in this view goes further and not only gages the boss again for size, but also tests it for accuracy of location as finished on the receiver. The gage spindle carries a hollow cup or ring at its lower end, which must pass over the boss while the receiver is fixed on its central plugs underneath.

What is probably a novel practice to many readers is adopted in the hardening of various points on the receiver. This is the spot-hardening with the oxy-acetylene torch for heating at the precise point where a hardened surface is necessary, the surrounding metal not being affected and the receiver being thus kept free from distortion.

Fig. 66 illustrates the internal-grinding operation with the wheel in the bore of the receiver and against the lock-up shoulder. The receiver is mounted upon an expanding mandrel carried in the lathe spindle and adjusted to grip the work by the bore by means of a draw-in plug operated by a rod and a handwheel at the rear end of the spindle.

This gage consists of two separate members which are combined in use to test the position of the shoulder. The gage head to the left is made up of a threaded sleeve which is adapted to screw into the thread milled in the receiver end, and in this sleeve is fitted a micrometer screw with large graduated head. The other member of the gage is a shouldered rod which is slipped into the rear end of the receiver to be ground and its shoulder or collar brought into contact with the lock-up shoulders which are to be finished with the wheel. The micrometer spindle may then be operated to bring it against the collar on the gage rod, and a reading taken on the dial to determine how many thousandths must be removed by the grinding wheel to bring the lock-up shoulders exactly the right distance from the receiver face.

FIG. 66. GRINDING THE MAGAZINE HUB ON THE RECEIVER

As explained in earlier installments of this article, the lock-up shoulders for the bolt are produced originally by a screw-machine operation, in which recessing tools are applied for forming an internal annular channel the rear face of which becomes the lock-up shoulders.

After the gage in this view has been applied to a receiver, as explained, and the amount to be ground off thus found by inspection of the micrometer dial, the work is placed upon the holding mandrel in the lathe

spindle and the internal-grinding wheel run into the bore until the starting of sparking shows that the wheel on its slender spindle is just in contact with the lock-up shoulders to be finished. A micrometer stop at the front of the carriage is then adjusted in accordance with the reading on the micrometer gage in making the preliminary measurement for position of the shoulder before the receiver is placed on its grinding arbor, and this carriage stop then allows the grinding wheel to be advanced the exact distance in thousandths required for finishing the shoulders to correct dimension from the face of the work.

FIG. 86. INTERNAL GRINDING IN FINISHING THE LOCKING SHOULDERS FOR THE BOLT

Cost-Plus Basis for War Supplies

By C. J. Morrison

On page 937, Vol. 46, of the *American Machinist*, there appeared an article by the present writer under the above title. All of the difficulties and dangers that were then pointed out in connection with the cost-plus method of payment have been encountered.

The costs of all such work have been extremely high. There have been and still are numberless questions as to what constitutes cost, and in some cases the plan has even defeated its own ends by slowing up the work owing to the excess of labor, which excess was sometimes so great that men could not work efficiently because of congested conditions and interference. This excess of labor was, of course, added to increase profits.

Probably the greatest difficulty has resulted from the unsettled condition of the labor market by reason of the exorbitant rates of pay that have been offered by contractors who were working on the cost-plus basis.

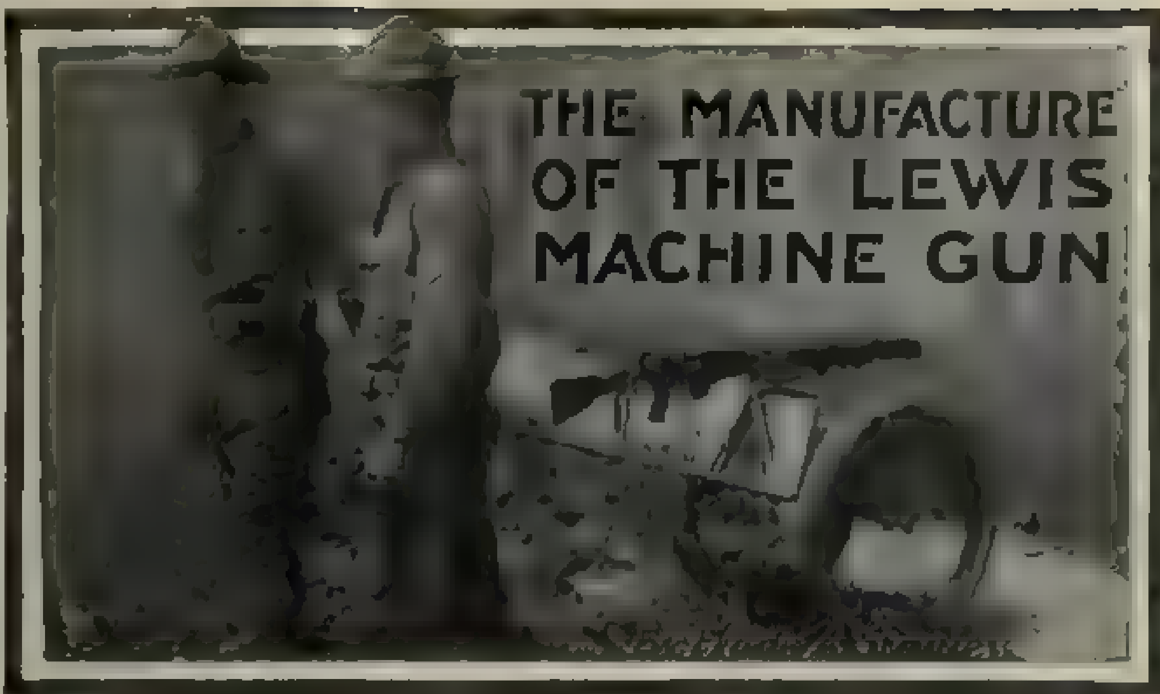
Rates were raised continuously, regardless of the fact that in many cases the work upon which the men were previously employed was quite as necessary to the conduct of the war as that for which the excess rate was offered.

Instances have been cited where contractors had actually been to other shops and endeavored to take men from their jobs by offering higher pay. Naturally these contractors were willing to pay the advanced rate as the more money they paid out for this purpose the greater would be their profits.

A recent proposal is to let contracts on a cost-plus fixed-profit basis which is a step in the right direction and will go a long way toward stabilizing conditions, but it would be better still to take one further step and allow the contractor to make a profit in excess of the fixed profit on condition of their reducing their costs below some predetermined standard.

The great flurry and general disturbance occasioned by the entry of this country into the war has now passed, and it should be possible to predetermine standard costs for all jobs and thus establish a basis for original profit as well as the chance for an additional profit.

If the contractor can materially increase his profits by decreasing his costs he will endeavor to get his work done for the lowest possible figure, and thus the confusion prevailing in the labor market will gradually be reduced.



VIII The Feed Cover—I

This member is made from a drop forging and has two small hubs machined at the rear and for locating in various fixtures and jigs. The engravings show typical tools and operations in profiling machines, drilling machines, etc., and illustrate gages for checking the accuracy of cuts.

THE feed cover of the Lewis gun fits over the top of the receiver and incloses the feed mechanism. It corresponds in general form to the upper portion of the receiver, and its contour is in fact made to the same dimensions as the exterior of the receiver platform, so that the two parts match up for the entire length of the cover which extends over two-thirds of the receiver length. The feed cover is a drop-forging which in its original form appears, as shown, to the left in the upper row of covers, Fig. 67. The work in various stages of progress, from the forging to the finished feed cover, is represented by the other members of the group in the illustration. The finished cover will be seen at the left of the lower row of parts or directly under the rough drop-forging shown in the upper row in the illustration.

Some of the various steps in the transformation of the piece from the rough forging to the finished article may be followed and should prove of interest to the reader.

There are over 60 distinct operations in the making of this feed cover as scheduled in the operation-sequence sheet which follows.

The feed cover is first ground on the bottom, then it is placed in a jig, Figs. 68 and 69, where three small bosses, or hubs, on the top face are hollow milled to form locating points for further operations. Two of these hubs are near the rear end of the feed-cover forging and the other is near the front. They are seen clearly on the covers shown in front of the jigs in Fig. 68. It will be understood that they form a three-point bearing for the work in other jigs and fixtures and that as the piece nears completion they are removed since they constitute no part of the finished feed cover. Two of the hubs will be noticed in the rough on the drop-forged cover at the upper left-hand corner of the group in Fig. 67. The third is produced in the jig by hollow milling down into the raised surface near the front end of the forging. The hubs are hollow milled to a diameter of ⅜ in., and the adjacent seats faced to 1⅜ in. in diameter.

Two jigs of the same construction are used under the spindles of the multi-spindle drilling machine, Fig. 68, each set of spindles carrying roughing and finishing hollow mills. One jig is shown opened, the other closed, and in connection with the illustration, Fig. 69, they show the general features distinctly. In the latter the work is shown resting against stops at side and end and secured by screws in the top and at the side. The top plate is secured when closed by three T-head clamp screws requiring only a quarter turn for fastening or releasing. The thumbscrew through the side wall for pressing the work sidewise against the rear stops is secured by a short binder handle which acts as a lock-nut.

The three small hubs hollow milled on the face of the feed cover are held closely to size and to the correct center distances apart, so that the work will locate properly in other fixtures. In Fig. 68 the knurled gage near the middle of the drilling-machine table is a limit gage for the diameter of the hubs. The rectangular block with upright vertical rod in front of the first

FIG. 97. THE FEED COVER IN VARIOUS STAGES FROM DROP FORGING TO FINISHED WORK

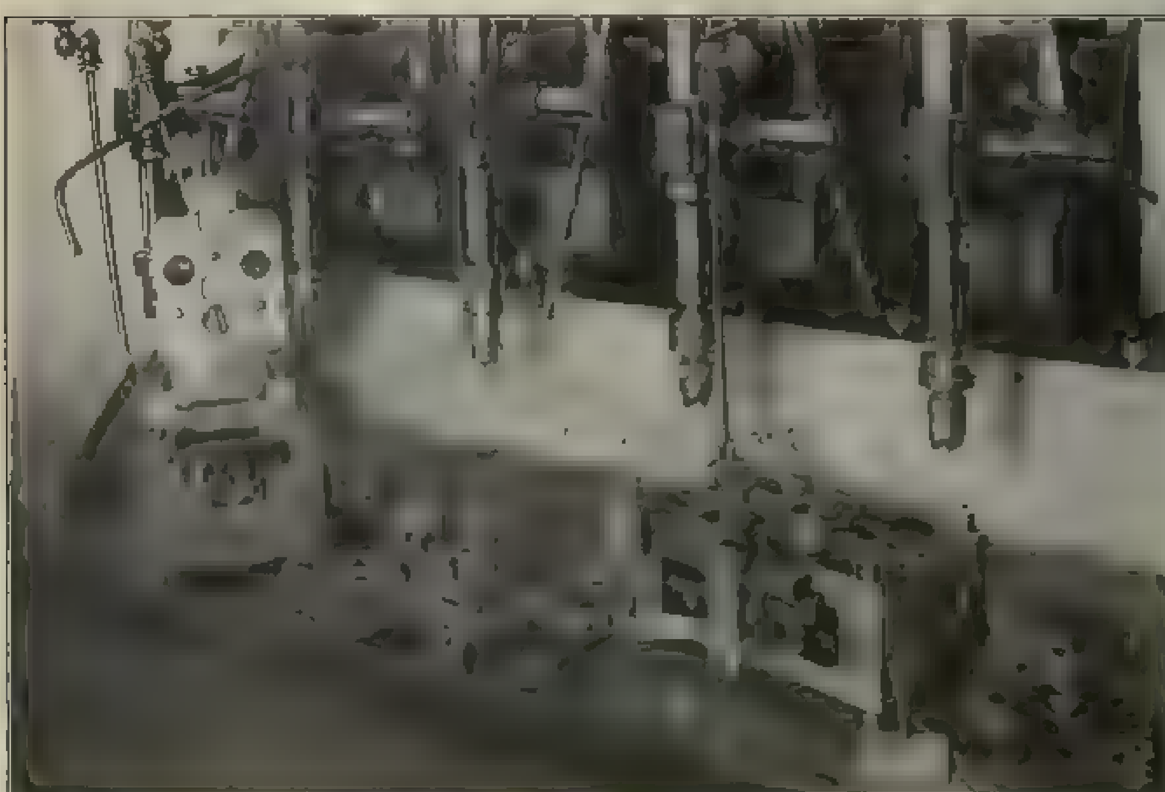


FIG. 98. JIGS FOR HOLLOW MILLING THE LOCATING HUBS ON THE FEED COVER

FIG. 71. PROFILING THE TOP AND THE SIGHT-LUG SIDES

Operation 8—The cover at the left is as it appears before the operation while the one at the right has been profiled over the top surface, across the shoulder in front and along the sides of the sight lug

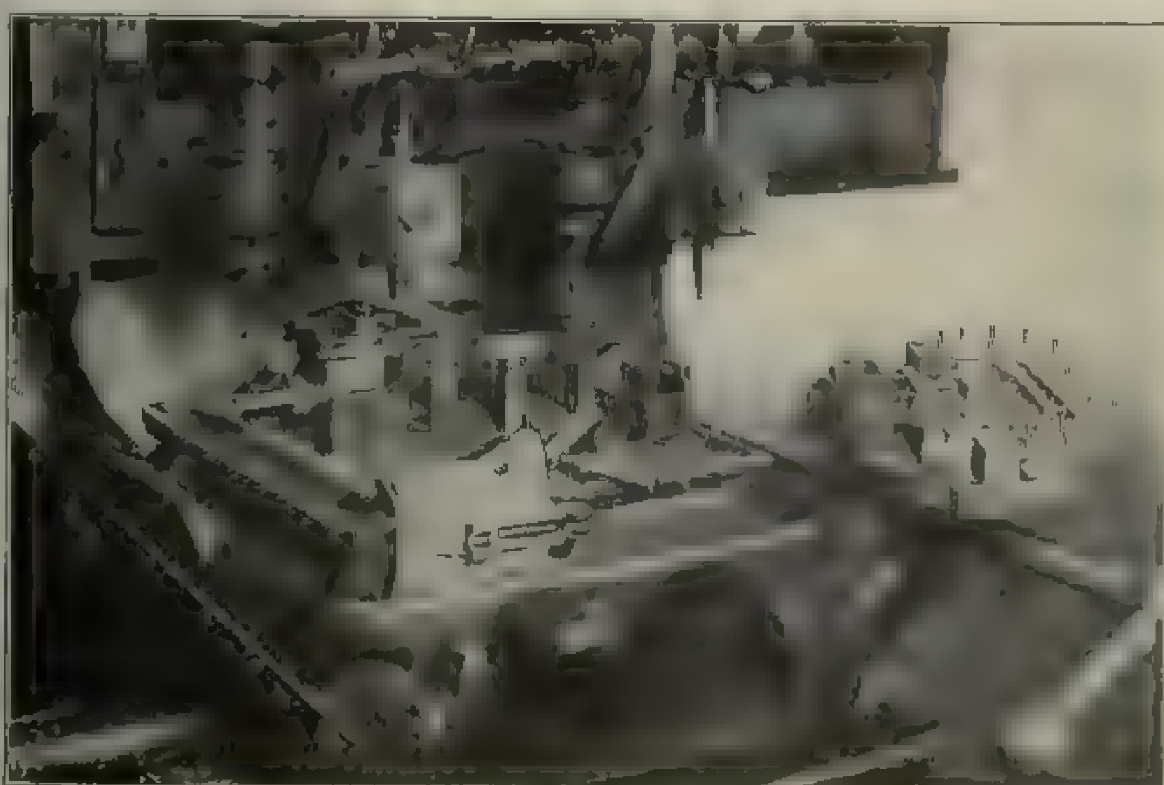


FIG. 72. PROFILING THE OUTSIDE OF [illegible] OF THE FEED COVER

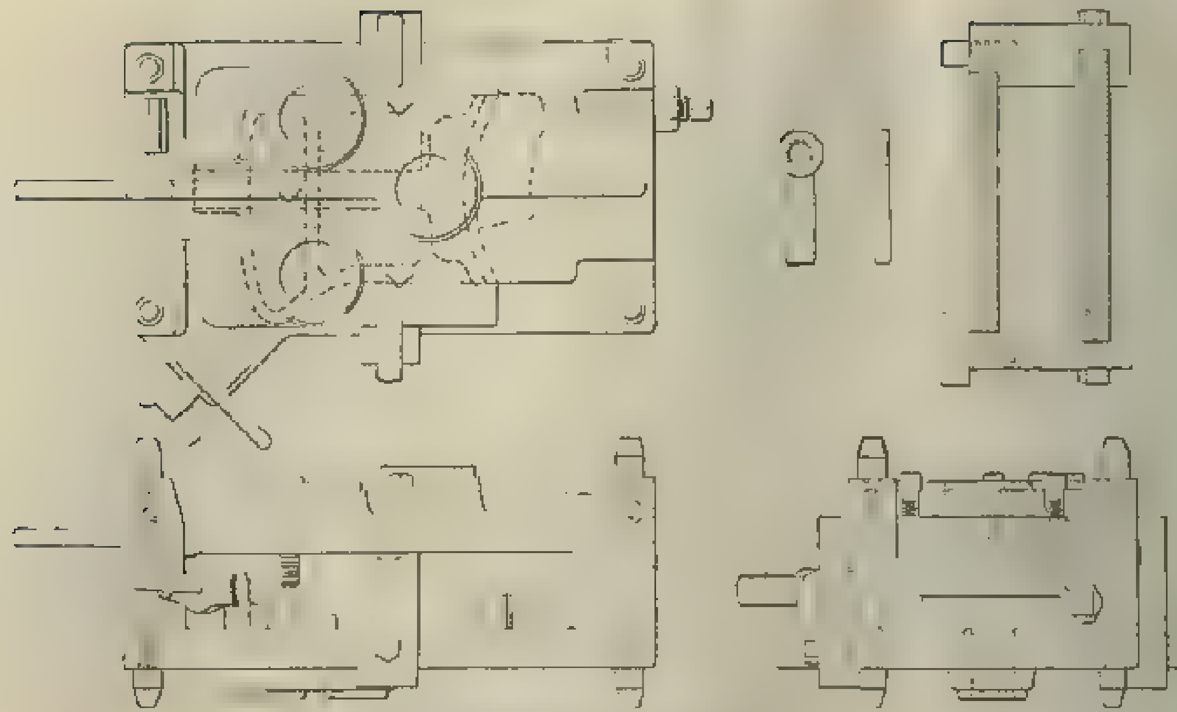


FIG. 69—CONSTRUCTION OF [illegible] GAGES

jig is a flush-pin gage for testing the depth of the seating cut from the top of the guide bushings. The gaging fixture at the right of the table is fitted with flush pins for testing the piece while it rests upon its three bearing points. The gage at the extreme left is a flat bar with two holes the right distance apart for testing the center distance of the two rear hubs.

The templet, Fig. 70, is fitted with two projecting bushings to fit over the rear hubs of the work and is shaped externally to correspond to the feed cover contour besides having numerous openings cut out to represent various lugs and surfaces on the face of the cover. This templet is applied to the feed covers as they come from the jig, Fig. 68, to make sure that all surfaces will machine up properly without an undue amount of metal at one spot and a correspondingly limited amount of stock at opposite points or surfaces of the work.

FIG. 70—TEMPLET FOR [illegible]

This templet may be applied to the work at any time to determine if the forgings in a given lot are being centrally positioned in the jig so as to leave a fairly uniform amount of material at all points, and any adjustments found desirable in this way are readily attended to.

The first profiling operation is illustrated by Fig. 71. This operation, No. 3, is the profiling of the top surface and of the sides of the sight lug of the shoulder at the front end, leaving stock on the forward lug or sight base for clamping. Two feed covers will be seen at the front of the profiling machine, one as it appears before the profiling operation, the other profiled over

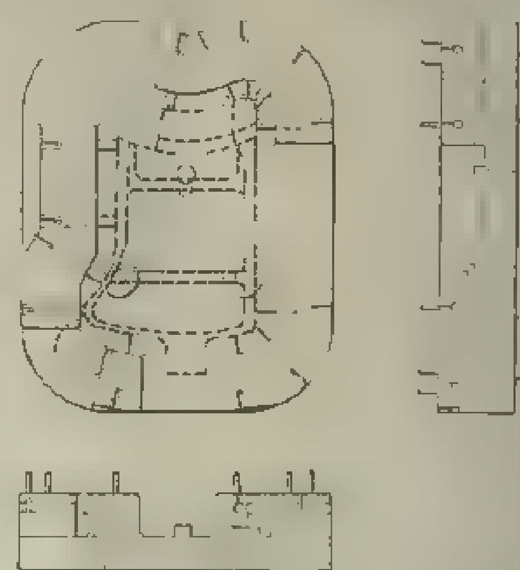


FIG. 73. A GAGE FOR THE FEED-COVER CONTOUR

the top surface across the shoulder in front and along the sides of the sight lug. The method of holding the work in the fixture is quite unusual and will be appreciated on examination of the fixture details in Figs. 71 and 72.

Upon referring to the latter illustration the feed cover will be seen at *A* located against the under side of the overhanging fixture brackets *B* and *C* by means of the two $\frac{3}{8}$-in. hubs formed in the hollow-milling process which enter hardened-steel bushings in the brackets. The other end of the work locates against a steel plug in the under side of a third bracket *D*. The work is pressed upward against the under side of the three brackets by a triangular shaped plate *E* and a long wedge *F*, which when pressed into place bears against the spherical face of a boss *G* at the center of the triangular plate *E*, so that the latter is forced up evenly against the under surface of the feed cover to be machined.

The two $\frac{3}{8}$-in. hubs on the top of the feed cover enter bushings in brackets *A* and *B*, the holes of which are lapped out to 0.376 in., so that there is only 0.001 in. clearance for each hub, thus assuring correct location of the work sidewise in the fixture. The $1\frac{5}{8}$-in. seats faced around these hubs by the hollow mill bear against the under surface of the brackets which are made to a radius of $\frac{3}{4}$ in. at their outer ends where the work takes its bearing, thus leaving ample clearance space for the profiling cutter used in surfacing the top of the work. The three bearing surfaces under the three brackets at front and rear bring the work perfectly level; and the clamping plate *E* having three projecting plugs in its upper face to take bearing against the bottom of the work secures the latter firmly without possibility of distortion when the operating wedge *F* is pressed into position.

The form plate for controlling the guide pin and movement of work under the cutter is clearly shown and needs no description. The gages for the profiling cuts are seen on the small tray on the right of the table in Fig. 71. The flat gage shown on edge tests the thickness and position of the sight lug, this gage fitting over the two $\frac{3}{8}$-in. hubs on the feed cover and therefore gaging the sides of the sight lug in respect to distance from the two hubs. The gage jaws are provided with pins, as indicated, which are brought into contact with the surfaces to be inspected. The long wedge and plate shown at the side of the gage are duplicates of the two parts used in holding the work up against the under side of the fixture brackets as previously described in connection with Fig. 72.

After the operation just described several other profiling and milling cuts are taken on the work. One of the profiling operations consists in milling two grooves along the sides of the front lug at the center of the plate, leaving a T head on this lug for future clamping purposes. That is, the lug is thus formed to the right shape to receive a clamping block which has a T-shape opening, allowing the block to slide over the T-section for the purpose of drawing the work down tightly in its holding fixture. One of these clamping blocks with the T-slot milled across its head is shown on the right-hand corner of the profiling machine table, Fig. 73, this view illustrating the fixture and method of profiling the outside shape of the feed cover.

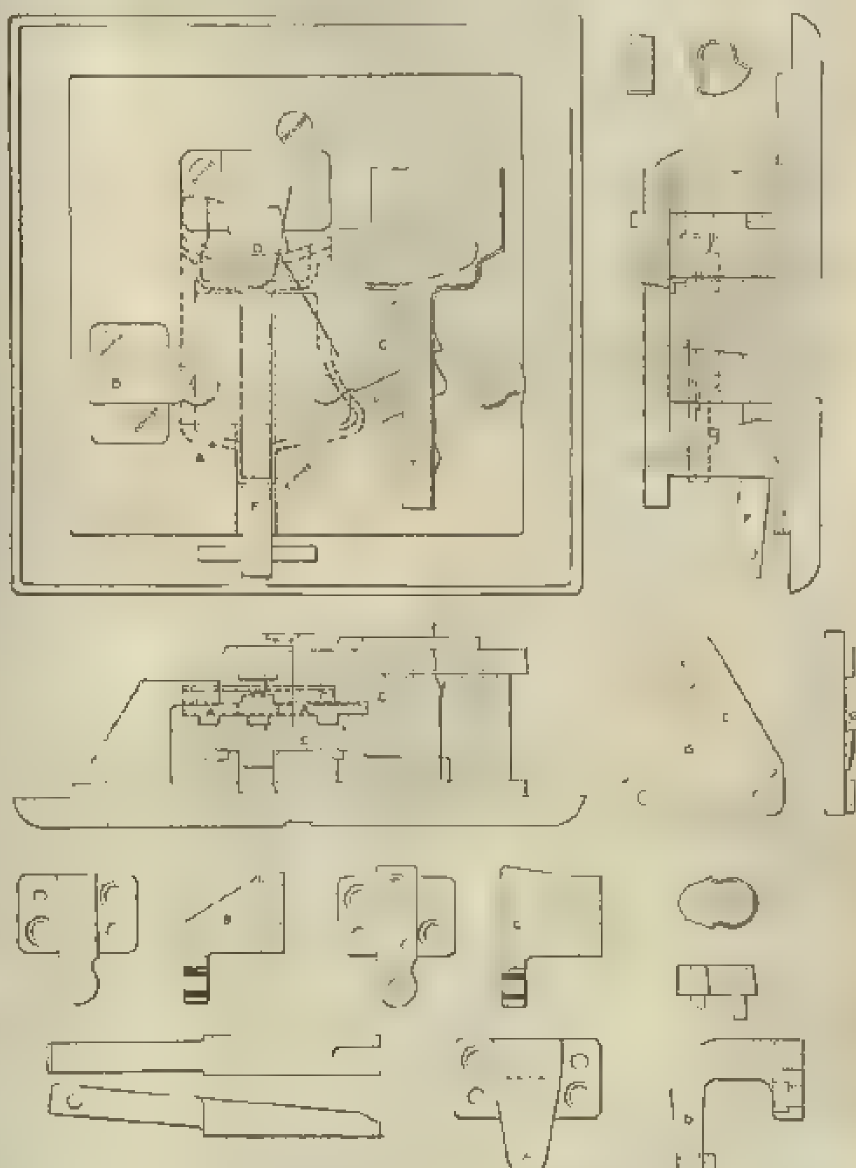


FIG. 72. THE PROFILING FIXTURE

An assembly drawing of the fixture and certain details are illustrated in Fig. 74, where the holding block with the T-opening referred to is represented at *H*. When the feed cover to be profiled around its edge is placed on this fixture the clamping block *H* is in uppermost position, allowing the sight-lug shoulders to slip into the T-opening, and the eccentric stud *I* is then turned over by its cross-handle to draw the work downward against the top face of the fixture with the ⅜-in. hubs on the work entered into the locating bushings *J* in the fixture top. These bushings are the exact size of the locating hubs, and they position the feed cover exactly on the center line of the holding fixture. The outline to which the feed cover is to be profiled is indicated by the contour of the form plate *K*.

SEQUENCE OF OPERATIONS

[illegible]
Hollow mill hubs to size and spot bearing at front end.
Profile top surface, sides of sight lug and shoulder at front end, leaving stock on forward lug or sight base for clamping
[illegible]
Profile top surface [illegible] and rear surface of forward end, leaving stock on forward lug or sight base for clamping
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Profile full outside shape
[illegible]
Drill and counterbore pawl spring and retaining hole
Profile underside of feed cover and outside shape of retaining lugs (rough).
Profile underside of feed cover and outside shape of retaining lugs (finish)
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Finish end of cartridge guide lug
Rough cartridge spring-guide clearance slot
Profile cartridge spring-guide clearance slot (second operation)
Profile cartridge guide lug cam surface (finish)
Profile radius cut on cartridge-guide cam surface
Mill cartridge guide spring clearance in end of lug
Profile rib and radius cut in cartridge guide lug
Grind for stamping operation.
Profile clearance cut at right side of pawl clearance and top of pawl hub.
Profile out stock at rear end of rib at magazine clearance slot for stamping.
Rough polish dovetail for stamping.
Roll in stamp name

Rough out pawl-clearance cut.
Hollow mill pawl hubs.

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Rough cut for operation [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
File to receiver gage
File crossbars and break inside corners
[illegible]
[illegible]
Rough polish flat surface
Drill cartridge guide-spring hole
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

In the articles describing the manufacture of the receiver of the Lewis gun, illustrations were presented showing a multiple flush-pin gage for inspecting the entire outside shape of the receiver at one setting in the gage. A similar type of gage for the same operation on the feed cover will be noticed at the right of the table on the profiling machine, Fig. 73, and the construction of this gaging device is brought out clearly in the illustration, Fig. 10.

The gaging fixture has a cast-iron base in which are inserted two hardened and ground bushings lapped out to 0.375 in. for locating the feed cover in the gage

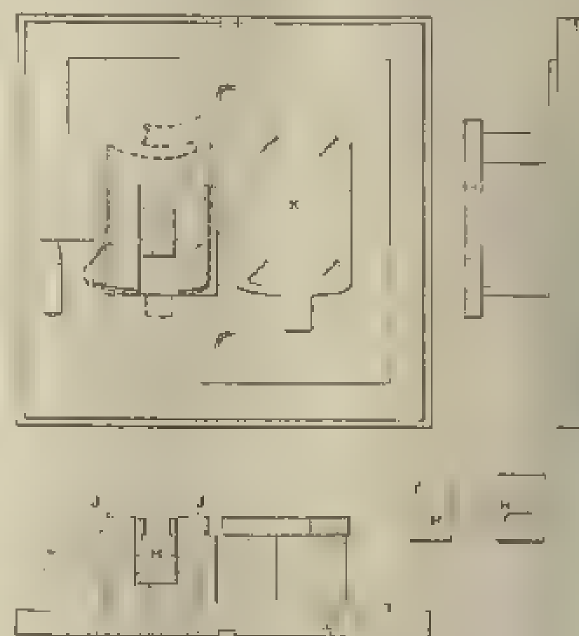


FIG. 74. THE FIXTURE FOR PROFILING THE OUTER SHAPE

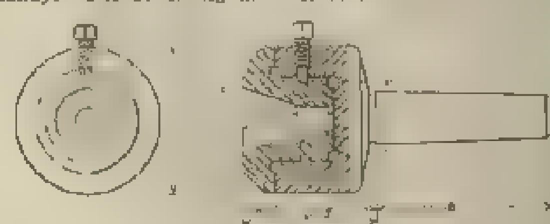
by means of its two small hubs which are a snug fit in the bushings. The front end of the feed cover rests, as in previous operations, upon a hardened plug located near the front on the center line of the fixture. The wide lugs which form the wall of the fixture are bored out to receive thirteen ¼-in.-diameter flush pins which operate at the proper angles to gage the various curves, slopes and straight lines that make up the contour.

Each of the flush pins is drilled crosswise for a small operating pin which slides in a vertical slot milled for a short distance in the top wall of the fixture.

Cup Center for Projectiles

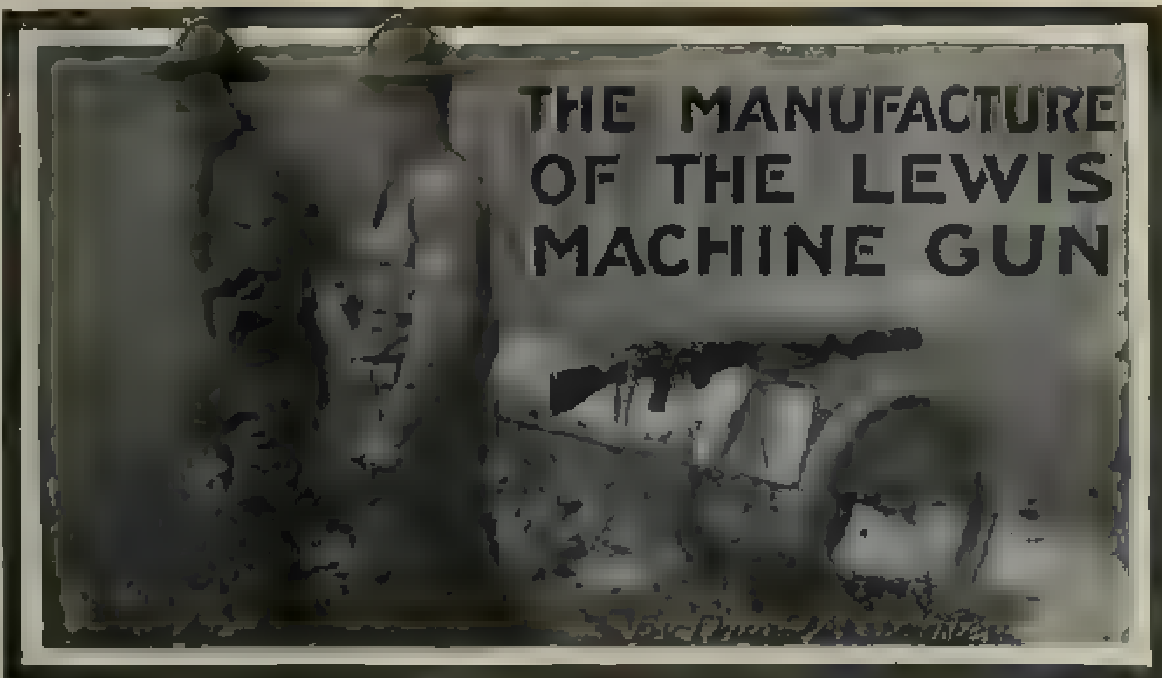
BY R. S. MYERS

For band turning on any type of shell the cup center design shown in the illustration will be found very handy. The revolving member *A* is fitted to the nose



CUP CENTER

of the shell and hardened. The shank is ground to fit the tailstock of the lathe. With a shell held in the chuck the cup center steadies it while the band is turned



THE MANUFACTURE OF THE LEWIS MACHINE GUN

IX. Feed Cover—II

This section of the feed-cover article shows a few of the operations in profiling the locking lugs, profiling the cartridge-spring clearance opening profiling the pawl-clearance slot, machining the sight lug, etc. The illustrations cover a number of important gaging devices which are essential in holding the parts to exact dimensions.

THERE are many other examples of important fixtures and gaging tools used in connection with feed-cover operations, but only a few more will be shown in this article. One of these, Fig. 76, is a fixture for profiling the locking lug on the right and left sides, the operation being No. 18 in the schedule. This fixture makes use of the same method for locating the feed cover by the ¾-in. hubs as described in connection with other tools, the bushings in the top of the fixture for receiving the hubs being clearly shown in the drawing. An eccentric shaft and a T-slotted clamping head are utilized, as in previous examples, for drawing the work down snugly to the fixture face. The eccentric shaft, it will be noticed, operates in a hardened and ground bushing fitted in the side of the fixture. An additional clamping device in this tool for steadying the front end of the work consists of a hook-shaped bolt which is drawn in from the right-hand side of the fixture by means of a large wing nut at the opposite side, the end of the work thus being gripped between the bolt head and a stop plug at the left to resist side thrust due to the action of the cutter.

The bolt is prevented from turning by a short cross-pin which enters a slot in the fixture and is released from the work by spring pressure when the nut is unscrewed.

A type of fixture in which the work is held at an angle for a profiling cut is shown in Fig. 77. The operation performed in this tool is No. 23, profiling the cartridge-spring guide clearance slot. This angular position is indicated in the drawing, which gives all important details of fixture construction. It will be noted that the method of locating and securing the work is the same as employed with the fixture last described. The chief points of difference as compared with preceding fixtures are to be found in the angular block which carries the work and in the shape of the slot of the form plate which receives the guide pin on the profiler head. Another profiling operation of interest is the milling out of the pawl-clearance slot, roughing and finishing cuts being required as in many other operations of similar character. The roughing of this cut is performed in operation No. 31. After the pocket or clearance has been roughed out two hubs of ¼ in. in diameter are formed in the bottom of the clearance cut by a hollow-milling operation, these hubs serving as pivots upon which are mounted later the stop pawl and rebound pawl for the magazine feed. The finishing of the pawl-clearance cut is attended to after these two small hubs for the pawls have been hollow milled to size and depth.

The fixture for both roughing and finishing the profiling cuts in the pawl-clearance seat is illustrated in Figs. 78 and 79. In the former illustration the work is shown undergoing the profiling operation, the auxiliary form plate for the guide pin for the other cut being shown swung up and out of the way of the lower form plate. The shape of the guide opening in the lower plate is best seen in the illustration, Fig. 79, where in the plan view the upper plate is shown removed.

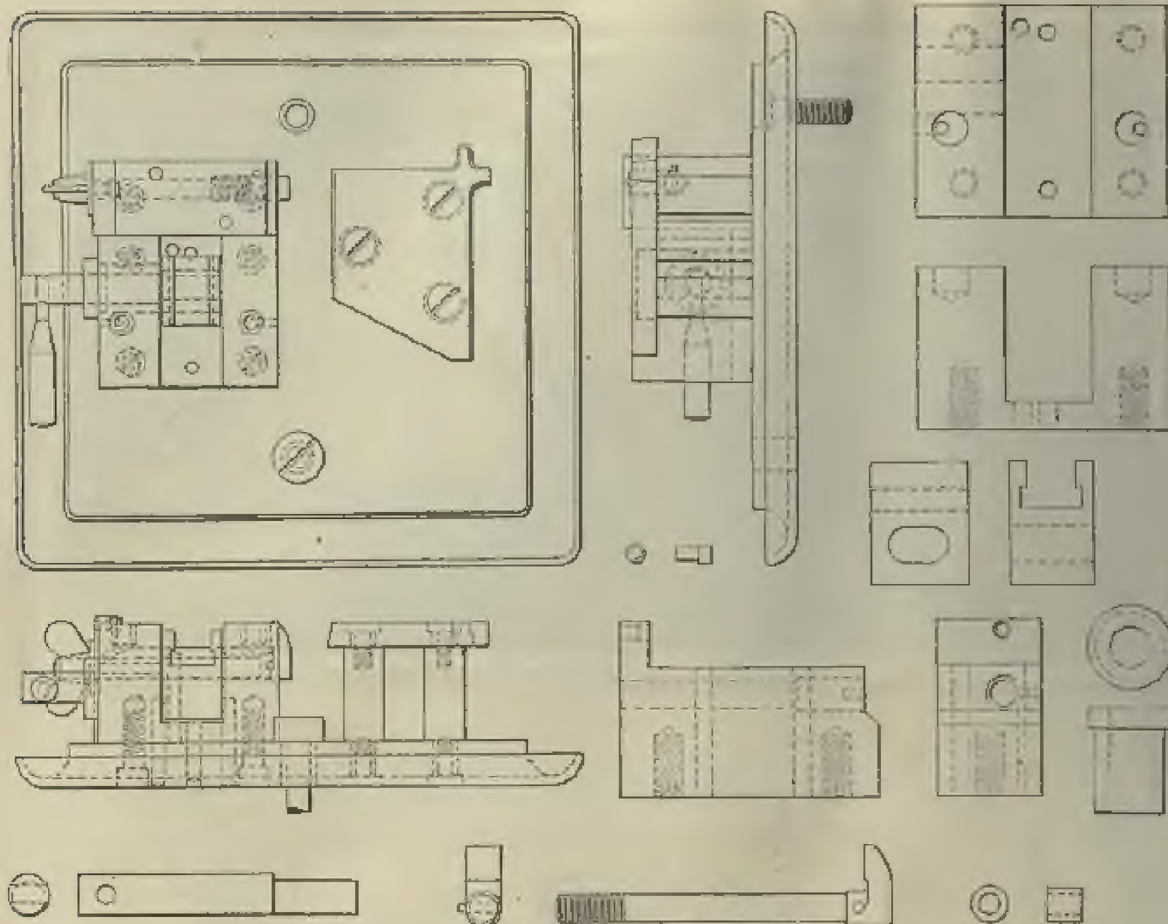


FIG. 76. FIXTURE FOR PROFILING LOCKING LUG

The shoulders C in the form plate B prevent the profiling cutter from working into the corners of the rectangular opening where are located the pawl-carrying hubs which are formed in the hollow-milling operation. The other plate A, having a rectangular opening without shoulders in the corners, allows the work to be operated upon around the entire edge of the rectangular seat. When the upper plate B is in service, it is held in correct alignment with the lower plate A by a stud, or pin, which is fitted in that plate and projects upward to engage the slot in rear end of the swinging plate B.

The method of holding the feed cover in this profiling fixture is similar to the one employed in connection with other fixtures that have already been described somewhat in detail.

The gaging of the work as it comes from this profiling fixture is accomplished with the device illustrated by Fig. 80 and the templet Fig. 83. The latter tool is made of $\frac{1}{16}$-in. flat stock fitted to a knurled handle and applied to the pawl-clearance opening to test its contour.

The gaging tool, Fig. 80, is in the form of a fixture whose base carries two $\frac{3}{4}$-in. bushings for holding the feed cover by the two hubs at the rear end or in the same manner as the work is located in the other fixtures illustrated. At the other end of the fixture base is a bracket with a long head, which is bored out vertically to receive four $\frac{1}{2}$-in. plugs, the lower ends of which are finished suitably to form contact-gaging surfaces while the upper ends are drilled to receive small operating handles. The lower part of each plug is ground at E to $\frac{1}{4}$-in.

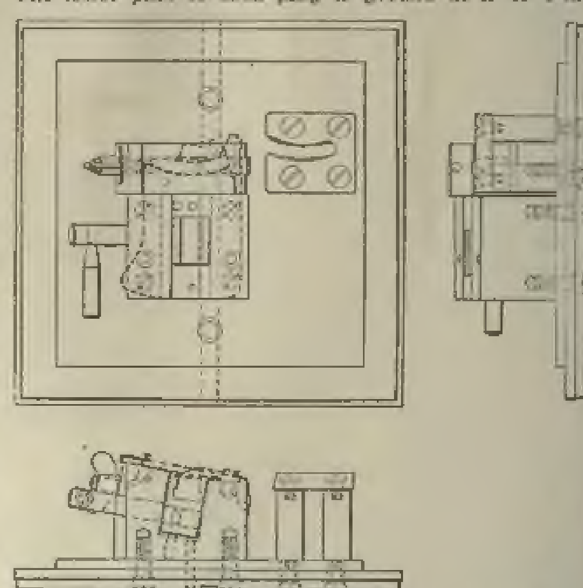


FIG. 77. PROFILING FIXTURE FOR CLEARANCE SLOT

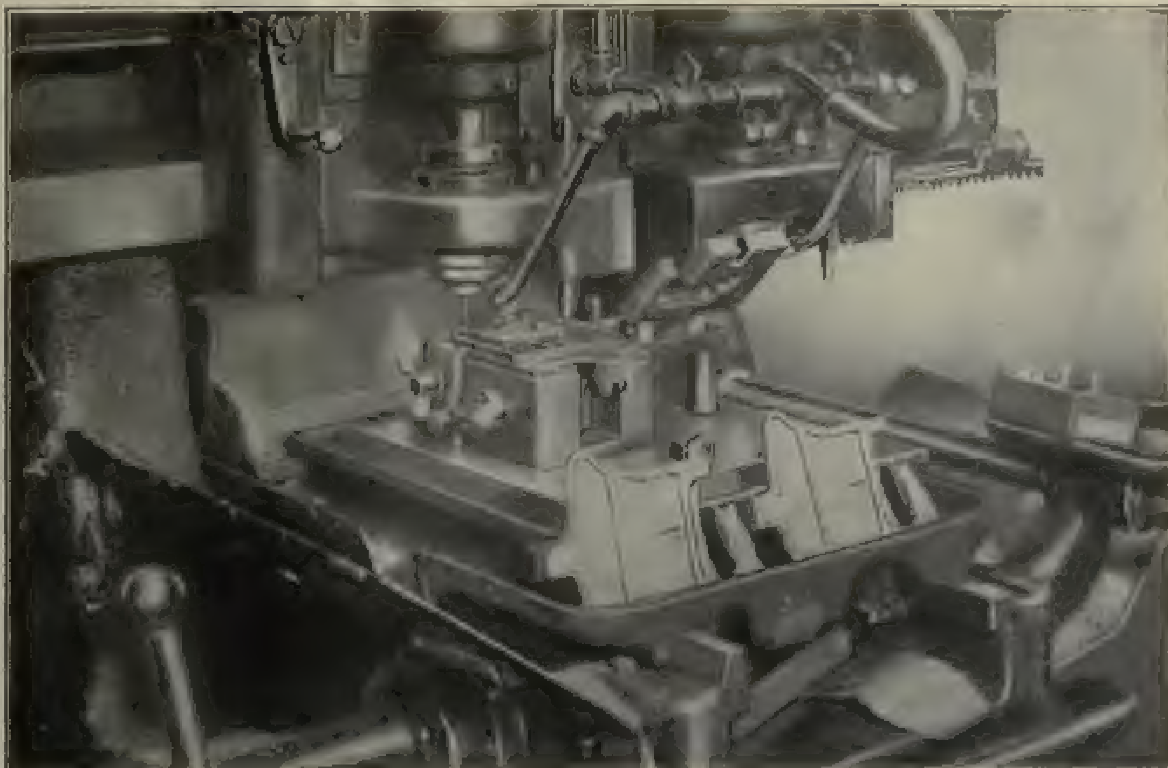


FIG. 78. A PROFILING FIXTURE FOR TWO DIFFERENT CUTS IN THE PAWL-CLEARANCE SEAT

diameter, and with this small end pushed down into contact with the pawl-clearance seat the upper end of the plug at *F* comes flush with the top surface *G* of the bracket head, so that the four plugs constitute a set of flush-pin depth gages for the bottom of the opening.

For gaging the sides of the opening for correct position each of the four plugs has a winged portion at *H* formed by flatting the sides of an enlarged shoulder, and when the plug is turned the ends of the wings provide a contact test for the profiled edges of the opening.

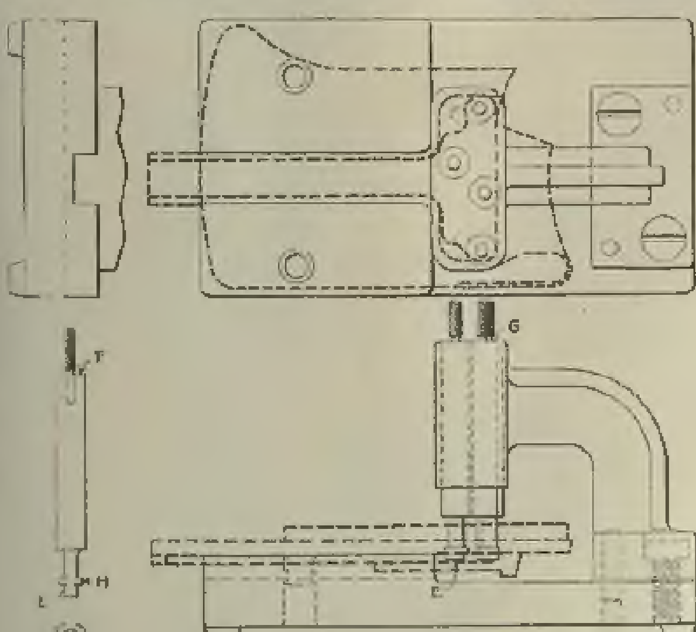


FIG.80

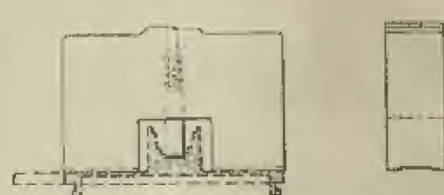


FIG.82

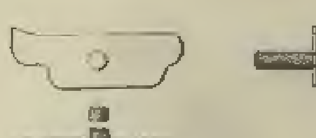


FIG.81

FIGS. 80, 81 AND 82. GAGES AND TEMPLETS

Fig. 80—Gages for the pawl-clearance opening. Fig. 81—Templet for contour of pawl-clearance opening. Fig. 82—Gage for seat cut in sight lug

Two of these plugs, it will be observed, are so located as to gage the ends of the cut, the other two the sides.

Following a number of operations on the sight lug and bed on the top of the feed cover the gage, Fig. 82, is applied to the work to test the spring-locking seat at the front end. This gage has a body which straddles the lug and carries at the middle a flush pin, the lower end of which contacts with the surface of the profiled seat.

One more operation is included in this article; this is operation No. 46; for profiling clearance for the sight-elevating screw. The fixture for this work and the method of holding the piece will be understood from Fig. 83. Here the feed cover is again located by its ⅝-in. hubs which enter bushings *H* in the overhanging brackets on the fixture. It is held up against the hardened and ground stop plugs in those brackets by the supporting plate *J* and the long wedge *K*. The supporting plate *J* is guided by three pins or posts *L* fixed in the base of the fixture, and it carries in its upper face hardened plugs which bear against the under side of the feed cover to be profiled. The profiling cutter itself is indicated at *M*. After certain other operations are accomplished the locating lugs (which up to this point have formed the means by which the feed cover has been properly positioned in the various tools) are cut off; then a number of hand operations, such as filing to gage and the like, are taken care of. The feed cover is then ready for hardening, sandblasting and browning.

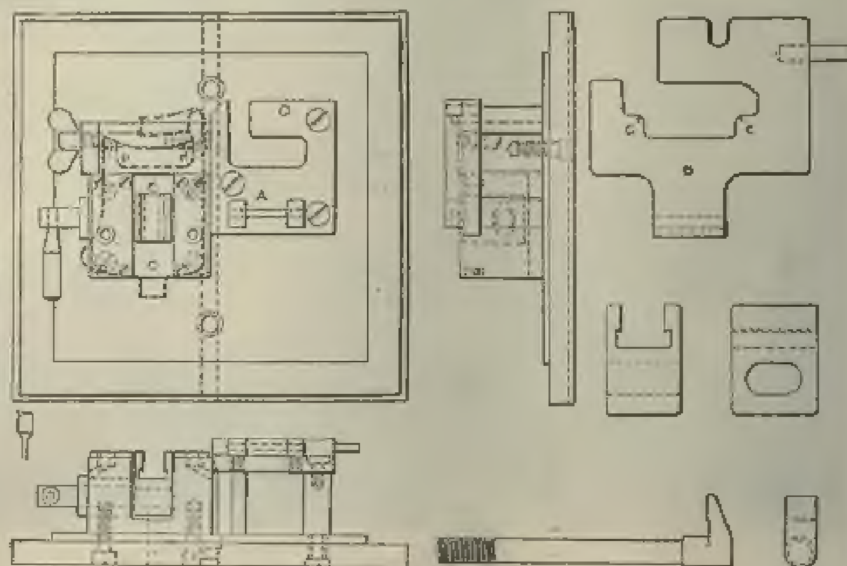


FIG. 79. DETAILS OF FIXTURE IN FIG. 78.

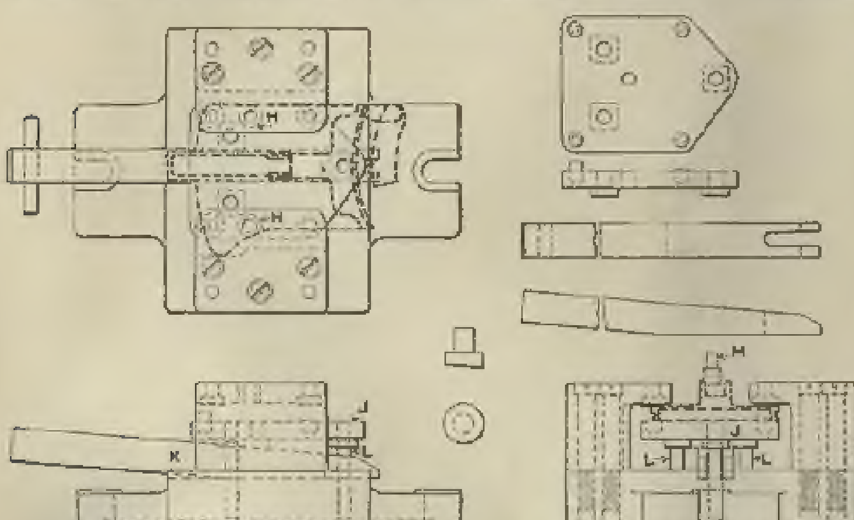


FIG. 83. PROFILING FIXTURE FOR SIGHT-ELEVATING SIDE CLEARANCE

The hardening is done as in the case of the receiver, only such spots as require hardening being heated.

Some Industrial Problems

By Entropy

In these days when the word democracy is on everyone's tongue, it is easy to be carried away by the word without thinking what it really means.

Real democratization of business would mean that every business enterprise would be a corporation the members of which had equal investments and all of whom would work in the business. These stockholders would elect their own board of directors, who in turn would elect representatives to conduct the business, and they would share equally in the profits or losses. The only thing that would make desirable the position of general manager of such a concern would be, if we leave out the chance for graft, the innate desire to stand in high places. Suppose a man wants the job, he will go about getting it in exactly the same way that a man endeavors to become mayor of a city. He will have the same proletariat to appeal to and they can be won in the same way. When he gets it his next problem is not production, but how to hold the job. In democracies the man who promises the most reforms and who caters to the crowd having the most votes stays on the job. Carrying out preëlection promises does not seem to count for much. The natural result of such methods of mismanagement would be the same as in municipal affairs; that is, the cost of doing anything would be practically doubled. Applied to business as a whole this

would mean that we could have about half as much for our money as we have now.

That is democratization of business. Who wants it? Only a few students of sociology and a few people who see in it a chance to loaf at the expense of the crowd. What the rank and file of us want is an opportunity to sell the only thing we have to sell—our efforts—where we can get a square deal. We want an open market without favors or privileges. Collective bargaining appeals to men only when they cannot see their way clear to get a square deal without it or when they expect to get something for nothing. When any man receives an income which he apparently does not earn we resent it, and this resentment is directed as much toward men who are drawing large sums from the Government shipyards for doing but a fraction of their duty as to the man who rolls by in his limousine. But it is not that the accumulation of wealth is resented by the rank and file so much as it is the manner of its acquirement. Most of us know that if we want to pay the price we can become at least moderately wealthy. If we are content to live singly, on the barest amount of food that will keep us alive, the least clothing that will protect us, and invest all our savings, even though at low rates of interest, by the time we are so old that we cannot enjoy anything we will have something to enjoy. Few of us envy wealthy people who have made their wealth by honest efforts. The ones to whom we object are those who have made it by sitting still and letting it rain on them. We cannot see why John Jones, who buys a vacant lot, should profit because Tom Brown builds a block on the next lot, and we cannot see why a lazy son should inherit the fortune his father acquired by sweating for it. The redeeming feature of this last case is that we know he will dissipate it very shortly.

What We Really Want

If we do not want to become rich by the only method we recognize as legitimate, and if we do not want to take the responsibility of jointly conducting a business enterprise, what do we want?

We want to be certain that we can draw the market price of our ware without having to bargain for it. We want the one-price system. Would any of us go back to the old store system where the prices were not stated in plain figures and where we knew that every price would be set by the clerk according to his estimate of our ability to pay? Not a bit of it. Then why not make our jobs one price? Not one price for everybody, but one price for every job. If I drive 2000 rivets in Boston and then move to Detroit why should I not get the same price there for the same job, barring differences in cost of living? We know that in four shops out of five there are different prices for the same work, as the matter of rate setting is left to foremen who are not in harmony with each other nor always consistent themselves. This refers to day rates, piece rates being usually set by men higher up; but even then they are a hopeless jumble of fat and lean, with the fat jobs handed to personal friends or dependents of the foremen.

What we need is better foremen, or better supervision of foremen so far as their relation to us is concerned. Whoever heard of a foreman being given any instructions as to how to be a foreman? or, for that matter, who could give such instruction? The superintendent is only a foreman promoted, with all the foreman's faults and some added abilities. The man to instruct foremen must not only have had a mechanical training but also experience in other parts of the organization, as the sales department, for example, where success depends on one's ability to meet other people on their own ground.

Our production departments are just beginning to find themselves in a position which is not new to the sales department. There constant shifting from a buyer's to a seller's market takes place. Salesmen have discovered that it is not wise to take their last ounce of flesh when things are coming their way, because the market always has changed in the past and probably will do so again. Foremen, however, cannot remember when there was an employees' market for labor, and they find it hard to realize the changed conditions. To be sure, in many instances their subordinates have become drunk with power and have done things almost as bad as the foremen themselves did before the balance of power swung away from them, but that is inevitable.

The Other Fellow's Position

The best way by which a foreman may know whether or not he is giving the workman a square deal is by putting himself in the other fellow's position. No man wants to work or should work where the conditions or the pace may shorten his working life or leave him to suffer after his working life is over. Steam power is so much cheaper than man power that there seems to be little excuse for using the muscles to anything like the tiring point, yet in many shops machines are placed away from cranes that might easily do the lifting and men waste their time doing it. Peace of mind is even more important than peace of body. Any man who is wondering when the boss will jump on him without provocation, or who is kept in fear that a slight slump in business will bring a layoff, will not be able to do his work as he should. Assurance of steady work and uniform treatment will solve many of the cases of high labor turnover which are so prevalent today.

Another thing which is not within the foreman's control but which is just beginning to come to the surface again is the fact that the best employees are those who have families. From the earliest days of factories it has been necessary to provide housing. Textile mills were obliged to go where there was water power, and it was necessary for them to build villages near their sites for their employees. The houses of this earlier day would not prove attractive now, for times have changed, and it is necessary not merely to provide a shelter, but there must be pleasant surroundings—schools, places of amusement and possibly churches, though the demand for the last mentioned does not seem to be so urgent as formerly. A company store where the operatives can procure their supplies is also necessary.

Taken altogether, it would seem as though much of the industrial unrest is due to lack of understanding as to what is taking place. We are fighting a great war, but right in our own shops we are passing through a tremendous revolution, and for the most part meeting it only by throwing out a bone now and then in the form of an increase in wages, thoughtlessly granted, too late to "beat them to it," and without due consideration of the true state of the labor market.